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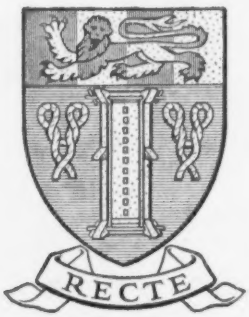

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The Journal of
Bone and Joint Surgery

EDITORIALS AND ANNOTATIONS

CONGENITAL DISLOCATION OF THE HIP

In the treatment of congenital dislocation of the hip we are confronted by a situation unusual in joint dislocations in general—an intracapsular dislocation in which there is an inherent incongruity between the femoral head and the acetabulum. Our problem therefore is something more than the simple manoeuvre of replacing a normally shaped articular end into a normally shaped socket through a hole in a recently torn capsule. In the young infant, before weight has been borne on the affected hip, this primitive incongruity presents a minor obstacle to the successful reduction of the luxation by the divaricator method introduced by Putti a quarter of a century ago. In Great Britain, however, the great majority of congenital hip dislocations continue to e cape diagnosis until the children have been walking for some months at least. In the older children the various developmental anomalies which comprise the anatomical picture of incongruity and which can be studied in arthrograms now assume an increasing mechanical importance as obstacles both to the concentric reposition of the femoral head in the socket, and its secure retention after reduction. A closer acquaintance with the detailed anatomy of congenital hip dislocations derived from arthrographic studies and from the increasing practice of open reduction has shown that in this deformity there are many different morphological types. Leveuf's simple concept of two distinctive types—the subluxation and the luxation—is no longer a safe guide to treatment and prognosis. As *Guilleminet and his associates (1952) have wisely said, each congenital dislocation has its own special morphology.

In recent years a pessimistic outlook has arisen in regard to the results to be expected from the treatment of congenital hip dislocations by the classical method of manipulative reduction, even when practised in children during the favourable age period—that is, under the age of three. One well established cause of disappointing results in apparently well reduced dislocations is the development of osteochondritic changes in the femoral head epiphysis. Although it has been clearly shown that osteochondritis is already present before reduction in some congenital dislocations, the " violence " of manipulation has been regarded by many as likely to be responsible for the ultimate deformity of the femoral head. This view is reinforced by the striking observations of Scott (published in this issue) that the incidence of osteochondritis has been reduced from 25 per cent to 8 per cent by the substitution of frame reduction for the manipulative technique previously employed at the Wingfield-Morris Hospital. In that hospital frame reduction has been successfully used in children up to the age of five. From the same orthopaedic centre comes quite a different attack on the problem of the reducibility of congenital hip dislocations—the revival of primary open reduction in young children. Somerville is impressed by the role of the inturned limbus in opposing

* Guilleminet, Stagnara, P., Fayssé R., et Bertrand, L. (1952): Revue de Chirurgie Orthopédique, **38**, 476.

reduction and stable retention, and in the series of twenty-three cases recorded here he has shown how this particular obstacle can be eliminated through a comparatively limited arthrotomy approach. His results are of course not yet long-term. The masterly analysis by Muller and Seddon of the late results of the treatment of congenital hip dislocations at the Royal National Orthopaedic Hospital over a period of fifty years is not only of intrinsic historical interest, but provides us with information of great significance. Their verdict that " there was reason for sober satisfaction with the results of closed reduction " is of prime importance in determining our future method of attack on dislocations in young children. It would appear that our aim should be to define as far as possible the special morphological features of each dislocation before attempting any type of reduction. This should enable us to recognise those cases in which closed reduction, whether by frame traction or gentle manipulation, is likely to fail completely or to result in an incongruent joint. Such cases will no doubt form a minority of the dislocations in young children; but in this group the technique of open reduction must be available.

Until we are able to diagnose and treat the dislocations in the first year of life, it is wise that we should not be tempted to adopt a perfectionist attitude in dealing with what is still a difficult problem. For as Muller and Seddon have pointed out, the " life " of a successfully reduced hip is about twenty-five years. On the other hand, the Royal National Orthopaedic Hospital follow-up has also reminded us that many adult patients with unreduced dislocations are able to lead an active and relatively comfortable existence. Such patients therefore should not become the victims of light-hearted surgical adventures. HARRY PLATT.

THE VASCULARISATION OF BONE

Investigations of the vascularisation of organs and tissues are useful from at least two standpoints. The normal distribution of vessels, apart from its purely anatomical interest, may be correlated with function (as shown, for example, by the work on the renal circulation carried out at the Nuffield Institute for Medical Research), or may assist the surgeon in evaluation of techniques. The examination of arterial anastomoses around or within the tissue is of importance for a comprehension of the efficiency of the collateral circulation which may be established during surgical procedures. In general, organs of endodermal origin, such as the stomach, intestine, thyroid, urinary bladder and pancreas, appear to be provided with particularly rich arterial anastomoses, but organs and tissues developed from mesoderm vary considerably in their reaction to ischaemia from the interruption of individual arteries of supply. The nearer to an organ an artery of supply is interrupted, the fewer the arterial anastomoses and the greater the likelihood of damage to the organ. Interruption of periosteal vessels, for example, would be more likely to lead to bone necrosis than occlusion of the common iliac artery, and it can be shown that interruption of the common iliac artery in the rat leads to no obvious change in the radiological appearance of the head of the femur up to four months after operation. The vascularisation of bone after periosteal stripping, or obstruction of individual periosteal vessels, would depend largely on the efficiency of intra-osseous anastomoses; but this particular aspect of the vascularisation of bone has led to many divergent statements in the literature. The investigation of the vascularisation of the head of the femur by Trueta and Harrison in this number of the Journal is therefore most welcome.

The arteries supplying the head of the femur are well known to the anatomist. The medial circumflex femoral artery in its course behind the neck of the femur gives off several periosteal branches, anastomoses with vessels from the posterior branch of the obturator artery and may furnish an artery passing along the ligamentum teres, or even entirely supplant the acetabular twig from the posterior branch of the obturator artery which is usually

considered to course along this ligament. Finally, the ascending branch of the medial circumflex femoral artery undergoes anastomosis with branches of the superior and inferior gluteal arteries in the region of the trochanteric fossa. On these grounds alone, therefore, the medial circumflex femoral artery should be more respected than the acetabular branch of the obturator. In addition, however, it is now clear that the medial femoral circumflex artery supplies most of the epiphysis and the whole of the metaphysis by way of its metaphysial and lateral epiphysial branches. A rich arterial anastomosis between the lateral and medial epiphysial arteries has also been clearly demonstrated (Figs. 3 and 23); the degree of efficiency of this anastomosis must obviously be considered in all cases of adduction fracture of the neck of the femur, but such an anastomosis is also of importance in the collateral circulation which may be formed as a result of arterial occlusion. Thus Olovson (Acta Chirurgica Scandinavica, 1941, **86,** Supp. 67) has shown that intra-osseous vessels as well as the periosteal network of vessels and the capsular arteries may show considerable dilation after ligation of the external iliac artery in the rabbit. The collateral channels that develop after such operations may be sinuous.

We are reminded of the mechanism of articular cartilage nutrition, since Trueta and Harrison confirm the existence of a subchondral circulation. Present anatomical opinion is in favour of nutrition from synovial fluid and, at the periphery of joint cartilage, by the circulus articuli vasculosus. Ekholm (Acta Anatomica, 1951, **11,** Supp. 15–2), however, from his studies with ^{198}Au, found that nutrition of rabbit joint cartilage most probably takes place partly from synovial fluid and partly via the direct contacts between subchondral vascular channels and the basal layers of the cartilage, but he was unable to establish the quantitative relation between these two methods. It would be unusual if such well demarcated subchondral vessels did not have some nutritional function, however small. The relationships on the two surfaces of the articular cartilage are almost akin to those seen in the varying morphological types of chorio-allantoic placentation, and Flexner and Gellhorn (American Journal of Obstetrics and Gynecology, 1942, **43,** 965) have shown that the smaller the number of tissue layers (including the endothelium of blood vessels) between maternal and foetal circulations, the greater the rate of transfer of radioactive sodium across a unit weight of placenta.

An anastomosis of intra-osseous vessels supplying the metaphysis and epiphysis of the head of the femur was described by Sappey 1873 (quoted by Poirier 1896), but refuted by Poirier (Traité d'Anatomie Humaine, 1896, tome II, fasc. II, p. 825) and others. There have been similar divergent opinions regarding the presence or absence of the arteria ligamenti teretis, and the extent of the vascularisation of the femoral head by this artery when present. It was once argued by Walmsley (Journal of Anatomy and Physiology, 1915, **49,** 434) that, since the femoral head undergoes " no especial atrophy " in the absence of the ligamentum teres in congenital dislocation of the hip, it cannot be held that the round ligament conveys a blood supply to the head of the femur. In cases of traumatic dislocation, however, atrophy does occur in at least a proportion of cases. These new findings open the way to a better understanding of such changes, and it may well be found that a further study of the vascularisation of the upper end of the femur in congenital types of dislocation may yield information of value concerning its etiology.

It is fortunate that we now possess such excellent methods as arteriography, which can be used experimentally to enable a precise examination of vascular patterns with facility, and the production of clear and decisive illustrations such as those shown by Trueta and Harrison. Arteriography has also been used to great advantage in the examination of the blood supply of the femoral shaft by Mr Gowans Laing as reported in his paper in this number of the Journal. The variations that exist in the nutrient arteries of bone are insufficiently recognised and must influence orthopaedic practice, and it is to be hoped that an extensive examination of other regions may be initiated. R. G. HARRISON.

LATE RESULTS OF TREATMENT OF CONGENITAL DISLOCATION OF THE HIP*

G. M. Muller, Ceylon, and H. J. Seddon, London, England

From the Institute of Orthopaedics, Royal National Orthopaedic Hospital, London

During the years 1949–50 a review was made of the results of treatment of congenital dislocation of the hip in patients dealt with at the Royal National Orthopaedic Hospital during the half-century ended in 1940. This was the era of closed reduction; the earlier cases were treated by pioneers, and at the Orthopaedic Hospital, at any rate, it was distinguished by an aversion from operative intervention. The risk of operation cannot have been a serious deterrent. There was only one post-operative death in the 100 operations of various types carried out on the *children* in the whole series. Thus either the powerful continental influence or private pessimism determined the prevailing conservative attitude. A number of members of the staff, in particular Laming Evans (1930), devoted immense pains to the practice of manipulative reduction; they followed their patients with great care, but there was no established machinery for securing their attendance for re-examination. Everything depended on the faithfulness of the surgeon and of patients and their parents. All notes were written by hand, and many of them were inadequate. Although the records of 889 cases were available, and every patient was invited to attend, only 264 were traced. The length of time that had elapsed since treatment, the vicissitudes of two wars (during the second all children were for a time evacuated from London), the normal movements of population, and deaths all contributed to the failure to trace over two-thirds of the patients. No more striking proof could be found of the need for a ruthlessly efficient follow-up organisation.

Our chief aim was to determine the fate of hips reduced by orthodox closed reduction, so as to furnish, if possible, a basis for assessment of the efficacy of the new regimen, namely, closed reduction as the primary means of treatment, and *early* operative intervention if closed reduction was not immediately successful, or if some anatomical abnormality of the reduced hip led to recurrence of the dislocation. At the same time the results of operative intervention were assessed.

GENERAL FEATURES

The sex incidence, frequency of involvement of either or both hips, and the relationship between the two are shown in Table I. This table brings out the comparability between the whole series of 889 and the 264 cases examined, as regards sex, incidence of bilateral involvement, frequency of right and left affected joints, and the combinations of sex and side.

Sex—The preponderance of females over males in the ratio of eleven to two in both series is similar to that reported by other observers. Of those with dislocation of one hip only, roughly five females were affected for every male, in both series. Of those with both hips affected, seven females were affected for every male, in both series.

One or both hips—The ratio of unilateral to bilateral dislocations was about two to one in the whole series and in the examined cases. In the unilateral cases there was a three to two predominance of the left side in the whole series; in the examined cases slightly more than twice as many left hips as right were found.

In both series, whereas the dislocation was bilateral in one-quarter of the males, one-third of all the females were so affected. Seven-eighths of the bilateral cases were in females both in the whole series and in the examined cases.

* A summary of this paper was presented at the Spring Meeting of the British Orthopaedic Association, Cambridge, 1951.

TABLE I

GENERAL STATISTICS

Sex incidence. Frequency of uncoleement of either or both joints

	All patients		Patients examined	
Sex	Males	140 (15·5%)	Males	42 (15·9%)
	Females	749 (84·5%)	Females	222 (84·1%)
	Total	889	Total	264
One or both sides	Bilateral	279 (31·4%)	Bilateral	92 (34·9%)
	Unilateral	599 (68·6%)	Unilateral	172 (65·1%)
	Total	878 (+ 11 cases unclassified)	Total	264
Sex incidence in unilateral cases		Right Left Total		Right Left Total
	Males	41 62 103 (17·2%)	Males	9 21 30 (17·4%)
	Females	183 313 496 (82·8%)	Females	45 97 142 (82·6%)
		(37·4%) (62·8%)		(31·4%) (68·6%)
Sex incidence in bilateral cases	Males	35 (12·6%)	Males	12 (13%)
	Females	244 (87·4%)	Females	80 (87%)
	Total	279	Total	92

TABLE II

COMPARISON OF DATE OF TREATMENT IN GROUP OF PATIENTS EXAMINED WITH THAT IN THE WHOLE SERIES

Year of first treatment	All patients		Patients examined	
	Number	Per cent	Number	Per cent
1891–1900	4	0·45	2	0·75
1901–1910	50	5·6	5	1·9
1911–1920	263	29·6	50	18·9
1921–1930	290	32·6	94	35·65
1931–1940	210	23·6	80	30·3
After 1941	72	8·1	33	12·5
	889	100%	264	100%

TABLE III

COMPARISON OF AGE AT FIRST TREATMENT IN CASES EXAMINED AND IN WHOLE SERIES

Age at first treatment	All cases		Cases examined	
	Number	Per cent	Number	Per cent
Under 3	284	32·4	130	49·2
3–5	155	17·7	60	22·7
5–10	170	19·4		
5–11	—	—	41	15·5
Over 10	266	30·4		
Over 11	—	—	33	12·5
	875		264	
Unclassified	14			
	889			

The reliability of the sample—To the extent of the evidence provided, therefore, the 264 cases actually examined were a fair sample of the whole. This sample, however, tended to be drawn from those who were first treated in more recent years, as shown in Table II.

The comparison indicates that the period of follow-up has been shorter in the sample; hence the results would tend to be more favourable. It may also reasonably be inferred that the quality of treatment for the sample was rather better because it was more recent; the results would again tend to be more favourable.

Furthermore, this sample tends to be drawn from those first treated earlier in life, as shown in Table III.

The condition was therefore treated earlier in the sample cases and the results would tend to be more favourable.

It will be gathered from the above arguments and figures that the patients examined tend to represent a more favourable section of the total and give a more favourable picture of the effects of the regimen of treatment.

Heredity—In twenty-eight of the 264 patients (10.6 per cent) there was an anterior or contemporaneous family history of congenital dislocation, a rather lower figure than that obtaining, namely 17·4 per cent, at the Rizzoli Institute, Bologna (Scaglietti 1939). One relative was affected in twenty-four of the twenty-eight cases, and two in each of the other four. The relationships of patients to the affected members of their families were as follows: great grandparents and grandparents 6, parents 7, uncles and aunts 6, siblings 6, cousins 7. There is, therefore, a direct hereditary influence (cases in which a parent is affected) in a quarter of the familial cases and in 2·65 per cent of the series. At the Rizzoli Institute the figure corresponding to the latter was 6·69 per cent; and Poli's figure for Milan, quoted by Scaglietti (1939), was 7·57 per cent.

Two of the twenty-eight (7·1 per cent) were only children whereas fifty-five (23·3 per cent) of the 236 with no family history were only children. The other twenty-six with a family history had ninety-eight siblings, and the other 181 with no family history 472. Patients with a family history therefore belonged to families having an average of 3·5 children, while those without a family history belonged to families with an average of 2·2. This seems to indicate that the presence of the anomaly in the family tree was no deterrent to the rearing of larger families, though it is in contrast with the figures relating to the younger generation of patients.

Fifteen of the twenty-eight patients who had a family history are married and have so far produced twenty-four children, none of whom is affected. Sixty-seven of the 236 patients with no family history are married and have produced ninety-one children, of whom four are suffering from congenital dislocation. In one the condition is bilateral, as in the parent, and in the other three the side affected is the same as in the parent.

Thus eighty-two parents had four affected children out of a total of 115. In this small series the risks of transmission were therefore as follows: 3·5 per cent of the children of affected parents will themselves be affected; 5·0 per cent of affected parents will have a child who is affected. A previous negative history is no guarantee against the appearance of the deformity.

Of the 264 patients eighty-two (31 per cent) are married and 182 unmarried. Fifteen of the eighty-two have a family history; twenty-two of the eighty-two families are childless, the remaining sixty families having 115 children in all. This makes an average of 1·4 children to each family, which, even allowing for the fact that some of these families were not complete, is lower than the figure for the country as a whole. According to the Report of the Royal Commission on Population (1949) dealing with the years between 1925–1929 the latter is 2·2 per family.

Of the 182 unmarried patients sixty-eight were under the age of twenty and would normally be expected to be single, although, in fact, two patients under the age of twenty are married but childless.

Co-existing conditions—Of the congenital conditions present eight (3 per cent) were club feet, and a like number of patients were mentally deficient (Table IV). The incidence of talipes is similar to that found by Scaglietti (1932, 1939) at the Rizzoli Institute. Anterior poliomyelitis had affected ten patients; this is a higher incidence than obtained in the general population but its significance, if any, is unknown.

TABLE IV

PATIENTS EXAMINED

Other co-existing conditions

Congenital		Acquired	
Mental deficiency	8	Poliomyelitis	10
Talipes	8	Torticollis	3
Multiple congenital deformities	5	Rickets	3
Cerebral palsy	3	Still's disease	1
Arthrogryposis	2	Tuberculosis of the other hip	1
Lumbar hemivertebra	1		
Diaphysial aclasia	1		
Thyroglossal cyst	1		
Klippel-Feil syndrome	1		
Diffuse port wine stain	1		
Anterior pituitary deficiency	1		

Birth presentation—Table V gives the mode of presentation of the foetus at the time of birth. Of the ninety-five cases in which this was known forty were breech presentations. Even assuming that this was the total number of breech presentations in all of the 264 cases the percentage is 15; the actual figure is probably higher. When it is recalled that the usual

TABLE V

PATIENTS EXAMINED

Birth presentations (264 patients)

Head	54
Breech	40
Caesarean	1
Unknown	169

incidence of breech presentations is 1·25 per cent it is hard to avoid the conclusion that there is some factor responsible for the high proportion of breech deliveries associated with dislocation of the hip.

DETAILS OF THE FOLLOW-UP PERIOD

Table VI gives the ages of the patients when they first attended for treatment at the Royal National Orthopaedic Hospital. Under 2 per cent came during the first year of life.

About one-third attended in the second and third years, another third between the third and tenth years, and a further third after ten years.

Table VII shows the decades in which patients were first seen at the hospital. The reason for the falling off of the figures in the decade starting 1931 is that no patient born after the end of 1936 was reviewed. Thus of the cases first attending after 1941 only those

TABLE VI

ALL PATIENTS

Age when first treated at the Royal National Orthopaedic Hospital (889 patients)

Age (years)	Number	Per cent
Under 1	15	1·7
1–3	269	30·7
3–5	155	17·7
5–10	170	19·4
Over 10	266	30·4
Unclassified	14	—

TABLE VII

ALL PATIENTS

Decades in which patients were first seen at the Royal National Orthopaedic Hospital (889 patients)

Decade	Number of patients
1891–1900	4
1901–1910	50
1911–1920	263
1921–1930	290
1931–1940	210
After 1941	72

born before 1936 are included; they came at a late stage of their condition and were of necessity atypical. It will be noticed that during the years 1911 to 1940 about twenty-seven new patients were seen annually.

Of those re-examined 130, or nearly half, had first come under treatment before the age of three (Table VIII) and roughly a further quarter under the age of five years.

TABLE VIII

PATIENTS EXAMINED

Age when first treated at the Royal National Orthopaedic Hospital or elsewhere (264 patients)

Age (years)	Number	Per cent
Under 3	130	49·2
3–5	60	22·7
5–7	28	10·6
7–9	8	3
9–11	5	1·9
Over 11	33	12·5

TABLE IX

AGE AT TIME OF REVIEW

(264 patients)

Age (years)	Number of patients
11–20	70
21–30	76
31–40	64
41–50	32
51–60	11
61–70	10
Over 70	1

Table IX shows the ages of patients at the time of the review; seventy were under twenty and fifty-four were over forty; 140, or over one-half the number, were between twenty and forty.

Table X shows the intervals between the completion of treatment and the final review. Calculations have been made from the time when plaster-of-paris fixation was discontinued,

TABLE X

FOLLOW-UP INTERVAL

(264 patients)

Interval (years)	Number of patients
Less than 10	10
11 – 15	73
16 – 20	58
21 – 25	36
26 – 30	35
31 – 35	20
36 – 40	12
41 – 45	2
46 – 50	5
More than 50	3

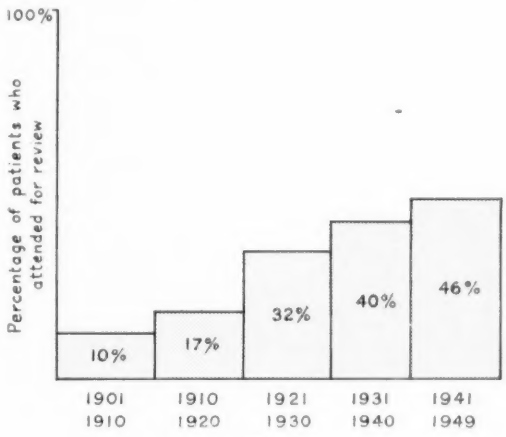

FIG. 1

Time of first attendance.

in those cases in which it had been used. In other cases the follow-up period dates from the year when the patient first attended a hospital for treatment.

Each succeeding decade shows a steadily increasing proportion of patients treated attending for re-examination (Fig. 1).

ASSESSMENT OF RESULTS

For the purpose of assessing results hips were classified in accordance with a scheme devised by St J. D. Buxton (personal communication) in connection with chronic arthritis of the hip, and slightly modified by us for this review. It resembles the method of grading described by Merle d'Aubigné (1952). The results are classified as follows:

Pain (P)

1. Severe.
2. Severe on movement; little at rest.
3. Some on movement; none at rest.
4. Slight on movement.
5. None.

Function (F)

1. Walks short distances only, with difficulty.
2. Walks half a mile; noticeable dip.
3. Walks two miles; slight dip.
4. Slight impairment of function.
5. Normal.

Movement (M)

1. Little or none.
2. Less than 50 per cent; fixed deformity.
3. More than 50 per cent movement; no fixed deformity.
4. Slight limitation of movement; no fixed deformity.
5. Full.

Radiographic anatomy (X)

1. Dislocation; ankylosis; osteotomy; excision head and neck.
2. Marked subluxation; gross deformity.
3. Slight subluxation; much deformity.
4. Slight subluxation; some deformity.
5. Almost normal.

A normal joint would thus be described as P5, F5, M5 and X5, scoring a total of 20 points. Each joint examined was allotted marks in this way, and from a consideration of the severity of pain, the amount of activity enjoyed, the range of movement and the radiographic findings, the joints were finally classified into four groups:

E—excellent or very good, where points obtained were 17 or over.
G—good, where the points obtained were between 16 and 14.
F—fair, where the points obtained were between 13 and 11.
P—poor, where the points obtained were 10 or less.

TABLE XI

GENERAL ANALYSIS OF TREATMENT

(264 patients)

Treatment	Number of patients
Closed reduction	155
Failed manipulation followed immediately by operation	6
Closed reduction followed by operation	23
Closed reduction; operation some years later	38
No attempt at reduction; later operation	15
No treatment	27

TABLE XII

PATIENTS EXAMINED

209 patients treated at the Hospital from the beginning

Age in years	Treatment designed to reduce the dislocation	Treatment not designed to reduce the dislocation
0–3	100	1 (Parents refused treatment)
3–5	42	1 (Not expected to live)
5–7	21	—
7–9	7	—
9–11	2	—
Over 11	—	35
	172	37

GENERAL ANALYSIS OF TREATMENT

Of the 264 patients re-examined 155 (Table XI) were treated by closed reduction alone. Six patients were operated on immediately after the failure of manipulation.

In twenty-three patients the period of plaster fixation was followed directly by operation, though sometimes the latter did not take place until four years from the time when treatment began. The infrequency of these operations and the protraction of the period of plaster fixation before they were undertaken is in sharp contrast with present day practice, when

every effort is made to determine within a year of the original closed reduction whether or not operation will be required to ensure a stable joint.

In thirty-eight cases operation was performed some years after the conclusion of the closed treatment.

In forty-two cases no attempt was made to reduce the dislocation but in fifteen of them operation was required sooner or later; twenty-seven had no treatment of any kind.

TABLE XIII

PATIENTS EXAMINED

172 patients (229 hips) treated from the first at the Royal National Orthopaedic Hospital

Age	Manipulative reduction alone		Manipulation followed by operation		Treatment abandoned	
	Patients	Hips	Patients	Hips	Patients	Hips
0–3	90	117	9	11	1	2
3–5	32	47	8	12	2	2
5–7	18	22	2	3	1	2
7–9	4	6	3	3	—	—
9–11	—	—	2	2	—	—
Total number of patients	144		24		4	
Total number of hips		192		31		6

TABLE XIV

PATIENTS EXAMINED

Fifty-five patients (seventy-six hips) treated early elsewhere

Age	Manipulative reduction alone		Manipulation followed by operation		Treatment abandoned	
	Patients	Hips	Patients	Hips	Patients	Hips
0–3	30	42	2	2	—	—
3–5	13	19	2	3	1	1
5–7	5	7	1	1	—	—
7–9	—	—	—	—	—	—
9–11	1	1	—	—	—	—
Total number of patients	49		5		1	
Total number of hips		69		6		1

Turning now to the patients treated from the first at the Orthopaedic Hospital, there were 209 cases, in 172 of which the aim was reduction of the dislocation (Table XII). Reduction was attempted in no less than nine cases over the age of seven. The details of the treatment at this early stage are shown in Table XIII.

In fifty-five cases the early treatment was carried out elsewhere; the details of treatment in relation to age are shown in Table XIV.

It will be seen that a total of 193 patients with 261 dislocated hips were treated by manipulative reduction alone while twenty-nine had manipulation followed by operation after a relatively short period. Of the former number, thirty-eight had operative treatment at a subsequent and relatively late period, leaving, up to the time of review, 155 treated by manipulative reduction alone.

DETAILED ANALYSIS OF TREATMENT

Manipulation—One hundred and ninety-three patients were treated by closed manipulation and of these thirty-eight underwent operation later. Of the 155 patients treated by closed methods alone (Table XV) 108 presented unilateral and forty-seven bilateral dislocations.

TABLE XV

PATIENTS EXAMINED

Results of manipulative reduction alone

Age (*years*)	Patients	Bilateral	Unilateral	All hips
Under 3	98	**29** Excellent 28 (48·3%) Good . 10 (17·3%) Fair . 14 (24·1%) Poor . 6 (10·4%)	**69** Excellent 45 (65·2%) Good . 10 (14·5%) Fair . 11 (15·9%) Poor . 3 (4·4%)	**127** Excellent 73 Good . 20 Fair . 25 Poor . 9
3–5	34	**13** Excellent 2 (7·7%) Good . 6 (23·1%) Fair . 14 (53·8%) Poor . 4 (15·4%)	**21** Excellent 10 (47·6%) Good . 6 (28·6%) Fair . 5 (23·8%) Poor . —	**47** Excellent 12 Good . 12 Fair . 19 Poor . 4
5–7	19	**5** Good . 2 (20%) Fair . 4 (40%) Poor . 4 (40%)	**14** Excellent 6 (42·9%) Good . 4 (28·6%) Fair . 3 (21·4%) Poor . 1 (7·1%)	**24** Excellent 6 Good . 6 Fair . 7 Poor . 5
7–9	2	—	**2**	**2** Good . 1 Fair . 1
9–11	2	—	**2**	**2** Excellent 1 Good . 1
Totals	155	47	108	202 Excellent 92 Good . 40 Fair . 52 Poor . 18

The results in this group are most interesting. In 80 per cent of unilateral dislocations treated before the age of three years the result was good, whereas only 65 per cent of the bilateral dislocations in the same age group were equally satisfactory. Taking the comparison a stage further it is found that 65 per cent of the unilateral dislocations gave excellent results, whereas the corresponding proportion of bilateral dislocations was 48 per cent. The contrast is even more striking for the three to five years age group, in which 76 per cent of unilateral dislocations gave good results as compared with 31 per cent of bilateral dislocations. Similarly, in the five to seven years age group 71 per cent of unilateral dislocations gave good results, whereas only 20 per cent of the bilateral dislocations were good.

Immediate open operation—Six patients in the series were treated by open operation immediately after failure of manipulative reduction. Of the nine hips operated on (Table XVI)

TABLE XVI

PATIENTS EXAMINED

Results in six patients (nine hips) treated by open operation immediately after failure of manipulation

Age (*years*)	Patients	Hips	Results
0–3	—	—	—
3–5	3	5	Excellent 1 Good . 2 Fair . 2
5–7	2	3	Fair . 1 Poor . 2
7–9	1	1	Good . 1
9–11	—	—	—

five were dealt with by open reduction, there were three shelf operations and one arthroplasty. The open reductions gave one good, three fair and one poor result. The shelves gave one excellent and two good results, whereas the arthroplasty was unsatisfactory.

Manipulation followed by operation—Table XVII shows the results in twenty-three patients who were treated by manipulation followed by operation at times varying between three months and four years after treatment began. In all these patients the operation followed immediately after the period of plaster fixation. The five excellent results all followed shelf operations performed between nine months and two years after the first application of plaster. Three of the six good results followed shelf operations and three followed open reductions. It will be noticed that only thirteen of these hips were operated on within a year of being put into plaster and when, presumably, the conclusion was reached that further immobilisation alone would not cure the condition. Of the bad results (which include fair and poor) in this group seven were in patients operated on before one year, and eight in patients operated on later. This seems to suggest that these cases were either intrinsically unfavourable or that some of them were operated on too late. Against the second supposition is the fact that there were two patients in this group who were operated on after only three months' immobilisation and yet the results were only fair.

Closed reduction, late operation—Thirty-eight patients, presenting forty-four hips (Table XVIII), were treated first by closed reduction but underwent operation some considerable time after coming out of plaster. In the 0–3 years age group 38 per cent showed very good or good results. The average interval between the time when they were first put into plaster and the operation was twelve and a half years. In the 3–5 years age group, 27 per cent showed excellent or good results, the average interval between the time when the patient was first put in plaster and the operation being eleven years. In the 5–7 years age group, 33·3 per cent of the cases showed a very good or good result, the average interval between the time when treatment started and the operation being twelve and a half years. Thus, almost irrespective of age these miscellaneous operations gave a uniform but low proportion of successes.

No reduction attempted: late operation—Fifteen patients were operated on at a later age. Four osteotomies of the Lorenz type, three arthroplasties, two rotation osteotomies, five arthrodeses and two shelf operations were performed. There was one patient on whom bilateral osteotomy of the Lorenz type was carried out; in another an arthroplasty was followed by arthrodesis.

TABLE XVII

RESULTS IN TWENTY-THREE PATIENTS (TWENTY-SIX HIPS) TREATED BY MANIPULATION FOLLOWED BY OPERATION

Age (*years*)	Type of operation	Results classified according to time interval between beginning of treatment and operation							
		3 months	6 months	9 months	1 year	1–1½ years	2 years	2–3 years	4 years
0–3	Shelf			Excellent					
	Shelf		Fair						
	Open reduction	Fair							
	Shelf			Excellent					
	Shelf						Poor		
	Shelf						Excellent		
	Shelf							Good	
	Open reduction						Poor		
	Shelf					Fair			
	Shelf (two)				Poor	Poor			
	Shelf							Good	
3–5	Open reduction								Poor
	Shelf			Excellent					
	Arthroplasty								Fair
	Open reduction		Poor						
	Shelf (two)					Poor		Poor	
	Shelf					Good			
	Open reduction (two)		Poor Poor						
5–7	Open reduction				Good				
7–9	Open reduction	Fair							
	Open reduction		Good						
9–11	Shelf					Excellent			
	Open reduction				Good				

The results in the sixteen hips were as follows: excellent, none; good, three; fair, four; poor, nine.

No treatment—Twenty-seven patients had no specific treatment. The behaviour of the thirty-three hips in this group was as follows: excellent, one; good, fourteen; fair, seven; poor, eleven.

RESULTS OF SPECIFIC OPERATIONS

Open reduction—Open reduction was carried out on seventeen patients (Table XIX). These operations were usually done because of failure of repeated attempts at manipulative reduction. In three cases, however (one of the patients aged sixteen years sustained a fracture

TABLE XVIII

RESULTS IN THIRTY-EIGHT PATIENTS (FORTY-FOUR HIPS) TREATED BY MANIPULATION AND OPERATED ON CONSIDERABLY LATER

Age when treatment started (*years*)	Patients	Hips	Operation	Average time interval before operation (*years*)	Results	
0–3	18	21	Osteotomy . . . 7 Excision of osteophytes . 2 Shelf . . . . 6 Arthrodesis . . . 2 Rotation osteotomy . 4 Arthroplasty . . 1 (one hip was operated on twice)	12½	Excellent 2 Good . 6 Fair . 3 Poor . 10	38%
3–5	10	11	Open reduction . . 1 Shelf . . . . 4 Cup arthroplasty . . 1 Arthrodesis . . . 1 Osteotomy . . . 5 (one hip was operated on twice)	11	Excellent 1 Good . 2 Fair . 4 Poor . 4	27%
5–7	8	10	Arthrodesis . . . 4 Shelf . . . . 3 Osteotomy . . . 3	12½	Excellent 1 Good . 2 Fair . 5 Poor . 2	33·3%
7–9	2	2	Osteotomy . . . 1 Open reduction . . 1 Sliding of great trochanter 1 (one hip was operated on twice)	13½	Excellent — Good . — Fair . 1 Poor . 1	

TABLE XIX

PATIENTS EXAMINED

Analysis of open reductions (seventeen cases)

Age at operation (*years*)	Patients	Hips	Reason	Results
0–3	3	3	Failed manipulation	Fair . 1 Poor . 2
3–5	5	7	Primary attempt at reduction Failed manipulation Instability	Fair . 3 Poor . 4
5–7	3	4	Failed manipulation	Good . 1 Fair . 1 Poor . 2
7–9	4	4	Failed manipulation	Good . 2 Fair . 2
9–11	1	1	Failed manipulation	Excellent
Over 11	1	1	Primary attempt at reduction (aged 16)	Fair
Total	17	20		Excellent 1 Good . 3 Fair . 8 Poor . 8

of the femoral neck during the procedure), the operation was the initial attempt to reduce the hip. On only two patients was the operation performed because the hip was found to be unstable though apparently reduced. In three cases the hand of the surgeon had been forced because of a fracture of the femoral neck sustained during manipulation; misguided attempts were made to align the fragments and to reduce the head at the same time, neither objective being achieved.

Hour-glass deformities were noted in six of these cases. The attempted open reduction was abandoned in three cases, in one at the second attempt. In two cases the head was remodelled, and in one a new acetabulum was gouged out; the subsequent history of these cases is dismal.

Four of the twenty hips in this series had excellent or good results. In ten the head subsequently absorbed to a considerable extent, while in one it enlarged after operation.

TABLE XX

FORTY-ONE OSTEOTOMIES IN THIRTY-THREE PATIENTS

Age at operation (*years*)	Rotation		Abduction		Adduction		Bifurcation (Lorenz, McMurray)	
	Hips	Results	Hips	Results	Hips	Results	Hips	Results
0–10	3	Good . 1 Fair . 1 Poor . 1	2	Poor . 2	1	Poor . 1	3	Fair . 2 Poor . 1
10–20	4	Excellent 1 Good . 1 Fair . 1 Poor . 1	5	Good . 1 Fair . 2 Poor . 2	1	Poor . 1	8	Good . 1 Fair . 2 Poor . 5
20–30	2	Poor . 2	1	Poor . 1	—	—	2	Fair . 1 Poor . 1
30–40	—	—	3	Good . 1 Fair . 1 Poor . 1	—	—	3	Fair . 1 Poor . 2
40–50	—	—	2	Poor . 2	—	—	1	Poor . 1
Total	9		13		2		17	

One patient had three osteotomies.
Six patients had two osteotomies each.
Twenty-six patients had one osteotomy each.

Eleven hips redislocated shortly after operation. In two cases the hip became extremely stiff soon after operation. In one Soutter's operation was required for a flexion deformity on both sides.

Four patients underwent subtrochanteric osteotomy subsequently to mitigate the degree of instability. In one case the resulting fixed adduction necessitated a later abduction osteotomy. On a boy aged sixteen a second operation was performed six years later, when the head was trimmed down to half its size and placed into what remained of the acetabulum; the end-result was fair.

Osteotomy—Thirty-three patients were subjected to a total of forty-one osteotomies (Table XX). Nine of these were *rotation* osteotomies; three were performed when the patient was less than ten years old, four between the ages of ten and twenty years. In three of them the site of operation was in the lower third, and the results in all cases were good. In three the site of operation was the middle third; the result in one case was excellent—in the other

two cases fair. In the remaining three hips, where the osteotomy was at the level of the upper third, the results were all poor—this is partly accounted for by the circumstance that two of these were performed on the femora of a child with multiple congenital deformities.

The fragments were wired on one occasion and plated in two others. In one case (two hips) the operations were done two years after the patient had first been put into plaster and six months after a shelf operation had been done on one side. All the other osteotomies were done a considerable time after the patient had first been treated by manipulative reduction.

Thirteen *abduction* osteotomies were performed, four for pain, six for instability and three for adduction deformity. The results were almost uniformly disappointing. In most cases the poor result was due to the original stiffness of the joint, but some of these patients were most unfortunate in ending up with a hip that was stiff in abduction, a most crippling deformity. The patient can only walk by tilting the pelvis so as to bring the abducted femur into a vertical position; in order to preserve his balance he acquires a compensatory scoliosis convex to the affected side, and when walking he has to swing the unaffected leg in a wide and grotesque arc, before bringing it down for the next step. In one unhappy case an adduction osteotomy was performed on the relatively sound side in order to bring the limb closer to its abducted fellow when the latter was taking weight. This made walking less ungainly but rendered permanent a considerable degree of pelvic tilt and a gross compensatory scoliosis.

Adduction osteotomies were performed on two patients, both for stiffness of the hip in abduction; in one patient following an open reduction and reshaping of the femoral head, which had been complicated by a mild infection; and in the other resulting from application of a spica in abduction for a prolonged period in a girl of twelve. The result in both was very poor.

A *Lorenz* type of osteotomy was carried out on seventeen hips, eight of them on patients between ten and twenty years. Eleven were for the relief of instability, four for flexion and adduction deformities and two for pain and stiffness in the joint. The results of these operations were disappointing, though symptoms and gait were improved in eight cases. Eight patients were unaware of any improvement. In one the operation was followed by an ankylosis of the joint in adduction; this patient was operated on at the age of forty-two, and the radiographs of her hips showed changes resembling those seen in ankylosing spondylitis.

One patient was subjected to three osteotomies on her two hips in order to correct flexion deformities; and six patients had two osteotomies each.

Shelf operations—Thirty-seven shelf operations were performed on thirty-six hips (Table XXI). The results were, on the whole, much better than those seen after other operative procedures; twenty-two (61 per cent) were good. No less than twenty-four of these operations were done after the age of five, and the proportion of good results was much the same before and after what is regarded—it would appear erroneously—as the upper age limit for the operation. All of these shelf operations were performed because of the inadequacy of the acetabular roof, and in twenty-six for instability that was clinically apparent.

Table XXII shows the sites of the shelves. An anatomically accurate lip was constructed in nine operations, and the results were correspondingly good—90 per cent. The shelf was slightly raised in twelve, and much too high in fourteen. The percentage of excellent and good results in these cases was 58 per cent and 57 per cent respectively; thus it appears that the periarticular disturbance resulting from the operation contributes appreciably to the subsequent stability of the joint.

The Bruce Gill (1928, 1935) type of shelf was constructed in twenty-two cases; a curved flap of iliac bone was turned down and held with a wedge also taken from the ilium. In two cases tibial bone was used for the wedge. In two other cases the iliac flap was turned down but no wedge was used. In a further eleven cases no record is available as to whether a wedge was used or whether the flap was left unsupported at the hinge.

TABLE XXI

Shelf Operations

Thirty-three patients (thirty-six hips), thirty-seven operations

Age at operation (*years*)	Patients	Hips	Results
0 - 3	5	6	Excellent 2 Fair . 1 Poor . 3
3 - 5	6	6	Excellent 1 Good . 4 Fair . 1
5 - 7	10	11	Excellent 4 Good . 3 Fair . 1 Poor . 3
7 - 9	5	5	Excellent 1 Good . 3 Poor . 1
9-11	2	3	Fair . 3
Over 11	5	5	Excellent 1 Good . 3 Fair . 1
Total	33	36	

Three cases appear twice in different age groups.
In one case two operations were performed on the same side, the second after an interval of eight years. The result given is the final one.

TABLE XXII

Analysis of Shelf Operations with Regard to Site of Shelf

(Thirty-seven operations on thirty-six hips)

	Hips	Result	
Site unknown .	1	Poor . 1	
Much too high .	14	Excellent 4 Good . 4 Fair . 3 Poor . 3	57%
Slightly high .	12	Excellent 2 Good . 5 Fair . 3 Poor . 2	58%
Anatomical .	9	Excellent 4 Good . 4 Poor . 1	90%

In one case there were two operations on the same side; the result given is the final one.

The timing of the operation in relation to the initiation of treatment is shown in Table XXIII. Seventy-five per cent of the operations performed within the first year gave excellent or good results; 45 per cent of the operations between one and three years were equally good; and 78 per cent of the shelves constructed after the lapse of three years. Thus the scope of the operation appears to be considerably greater than we have recently come to believe.

TABLE XXIII

TIMING OF SHELF OPERATIONS IN RELATION TO THE INITIATION OF TREATMENT
(Thirty-seven operations on thirty-six hips)

Interval after first application of plaster	Hips	Result	
1 year or less	8	Excellent 4 Good 2 Fair 1 Poor 1	75%
1–3 years	14	Excellent 3 Good 3 Fair 3 Poor 5	43%
3–7 years	8	Excellent 2 Good 5 Poor 1	87·5%
Over 7 years	6	Excellent 1 Good 3 Fair 2	66%

In one case there were two operations on the same side; the result given is the final one.

Thirteen shelves were entirely absorbed, yet in five of these cases the result was good. Fourteen were partly absorbed, the excellent and good results numbering ten. Nine shelves were unabsorbed, and eight of these gave excellent or good results. Here is further evidence, in addition to that furnished by the levels of the shelves, which indicates that soft tissue changes, in the main fibrosis, must contribute considerably to the stability of the joint which is the aim of the operation.

THE C.E. ANGLE

The C.E. angle was first described by Wiberg (1939) and elaborated for the hips of younger patients by Severin (1941). It is the angle between a line drawn through the centre (C) of the femoral head in the longitudinal axis of the body and another line joining this centre to the lateral edge (E) of the acetabular roof (Fig. 2). This angle is the measure of the extent to which the acetabulum contains the femoral head. After fourteen years of age 25 degrees is the lowest figure for the normal hip. From 20 to 25 degrees is an "uncertain" range, in that there is a tendency for the hip to subluxate; and figures below 20 degrees are definitely abnormal. This measurement is useful as an expression of the development of the acetabular roof and of the stability of the femoral head in its socket.

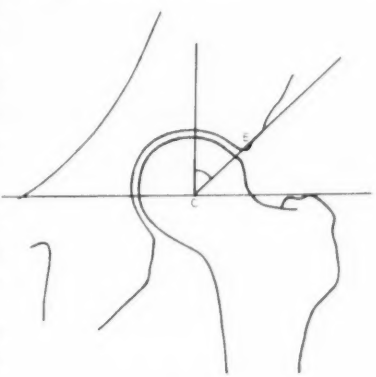

FIG. 2
Diagram showing the C.E. angle.

The C.E. angle on the affected side was measured in 143 cases in our series, all of them over the age of fourteen. In forty-six the angle was 25 degrees or more, and in ten of these there was some degree of

subluxation. In fifteen the angle was between 20 and 25 degrees, the "uncertain" range of Severin; seven had subluxated. Forty-three hips had a C.E. angle of between 10 and 20 degrees, and twenty-six had subluxated. Thirty-five of the thirty-nine hips with a C.E. angle of less than 10 degrees had subluxated. Thus although a good acetabular roof is a most important factor in the maintenance of a stable reduction, it is not an absolute safeguard against subluxation (Fig. 3).

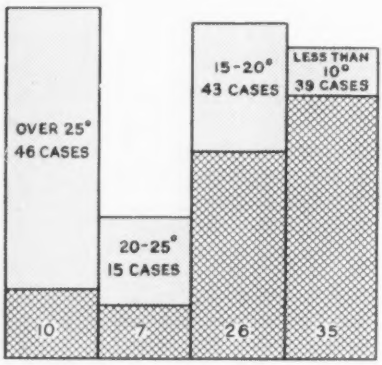

FIG. 3

Relation of the C.E. angle to subluxation. The cross-hatched areas represent cases in which subluxation occurred.

The C.E. angle on the sound side was measured in cases of unilateral dislocation. The following variations were found: the angle was 5 degrees in four cases; between 5 and 10 degrees in four cases; 10 to 15 degrees in nine cases; 15 to 20 degrees in eleven cases; and 20 to 25 degrees in three cases.

Thus in twenty-eight out of 172 "sound" hips, one would suppose that a well marked tendency to subluxation was present, while three cases were in the "uncertain" group. Here, therefore, is evidence from the opposite direction that an acetabulum of good shape is not indispensable to the stability of the hip. However, the thirty-one cases mentioned above might well be considered to show minor degrees of aplasia on the supposedly sound side, the sort of condition which leads not infrequently to osteoarthritis at a relatively early age.

ANTEVERSION

The other important anatomical feature in relation to stability of reduction is anteversion of the upper end of the femur, more especially the femoral neck. An attempt was therefore made to estimate the degree of anteversion in each of the cases examined, and to assess its possible significance. Seddon and Trevor (unpublished work) have found that even in the early case of congenital dislocation the various methods of estimating anteversion are surprisingly unreliable when checked by the accurate measurements made at operation. Thus it would be improper to give figures carrying an appearance of refinement. A well known simple clinical method of measurement was used, and all but grossly abnormal figures were disregarded. The patient lay face down with the knees bent at right angles; the examiner held one ankle in one hand, the other hand being placed over the great trochanter. The foot was then moved through an arc until the prominence of the trochanter was maximal. The deviation of the line of the tibia from the vertical was then measured and compared with that on the opposite side, an angle of more than 45 degrees being considered abnormal. In bilateral cases such a comparison is not possible, and one must be content with direct measurement, an inclination of not less than 60 degrees from the vertical being considered significant.

A radiographic method was used in some bilateral cases, and when limitation of medial rotation was a hindrance to clinical measurement.

One hundred and twenty-eight (83 per cent) of the 154 hips which showed a notable degree of anteversion were associated with more or less subluxation of the head or with frank dislocation.

The unilateral cases are the best group for analysis. Ninety-five (55 per cent) of 172 unilaterally affected hips showed anteversion. Twelve of these cases had had no early treatment; eighty-three treated hips (52 per cent), therefore, showed a significant

degree of anteversion. Fifty-eight (70 per cent) of these anteverted hips had subluxated (Table XXIV).

Of the seventy-seven unilaterally affected hips which showed no anteversion eighteen had had no treatment; two others are excluded on account of inadequacy of the case notes;

TABLE XXIV

RELATION OF ANTEVERSION TO SUBLUXATION IN 140 TREATED HIPS

	Anteverted (83)	Not anteverted (57)
Subluxated	58 (70%)	27 (47·4%)
Not subluxated	25 (30%)	30 (52·6%)

twenty-seven (or nearly half) of the remaining fifty-seven treated hips showed some degree of subluxation. The difference in the ratios is just sufficient to warrant the assumption that anteversion is a factor in causing subluxation after reduction.

OSTEOARTHRITIS

One hundred and thirty-eight patients showed radiographic evidence of osteoarthritis. The relationship in 136 of these cases between the configuration of the joint at the time of examination and its function is set out in Table XXV. As would be expected, the figures suggest that the better the anatomical state the better the function as a whole.

TABLE XXV

RELATION OF ANATOMY TO FUNCTION IN 136 CASES OF OSTEOARTHRITIS, AND RELATION OF ANATOMY TO PAIN IN SEVENTY-SEVEN CASES IN WHICH THERE WAS A COMPLAINT OF PAIN

	Total number	Function					Number with pain	Percentage with pain
		F5	F4	F3	F2	F1		
Dislocated (femoral head one inch or more above line of acetabulum)	59	—	9	31	12	7	37	63
Subluxation (head half to one inch above line of acetabulum)	30	1	4	16	8	1	17	57
Slight subluxation (head less than half an inch above line of acetabulum)	30	4	8	8	10	—	16	53
Concentric	17	9	—	3	5	—	7	41
	136						77	

PAIN

Seventy-nine patients with osteoarthritic changes complained of pain, and the time of onset is shown in Table XXVI. However, Table XXV, which refers to seventy-seven patients, shows that although there was a slight tendency for the anatomically better hips to be less painful, the complaint of pain was fairly uniformly distributed on an anatomical basis. Thus the superior function of the anatomically better hips was due to factors (for example, walking distance) other than the absence of pain. Thirty patients had pain in the absence

of osteoarthritic changes; in sixteen of these the joint was frankly dislocated and seven more showed varying degrees of subluxation. In one case the muscles around a soundly arthrodesed joint were the site of pain.

TABLE XXVI

OSTEOARTHRITIC CHANGES AND PAIN

138 showed radiographic changes but only seventy-nine of these were affected by pain

Age at onset of pain (79 cases)	Number of patients
Before 20 years	15
21–30 years	20
31–40 years	34
41–50 years	5
Over 50 years	5

GENERAL DETERIORATION OF THE DISLOCATED HIP

In an analysis of the results of treatment of a non-lethal condition such as congenital dislocation of the hip, the merits of a long-term review are twofold. The date of review is sufficiently remote from the period of active treatment to ensure that the consequences of whatever has been done are reasonably permanent; in addition, sufficient time will have elapsed to reveal any slow deterioration (or improvement) that must, of necessity, be taken into account in framing a prognosis. It is common knowledge that after the ups and downs of the decade following treatment of a congenitally dislocated hip the general tendency is towards deterioration of the joint. So far this analysis has not been concerned with the durability of the deranged hip. The specific effects of various procedures are known; it is now necessary to determine what, in a general way, may be regarded as the useful "life" of the joint. Figure 4 shows that most hips continue unchanged until the sixth quinquennium of life. Between the ages of, say, twenty-three and thirty-three years nearly half of the satisfactory joints become troublesome in one way or another. However, after that age the survivors continue fairly happily into middle life.

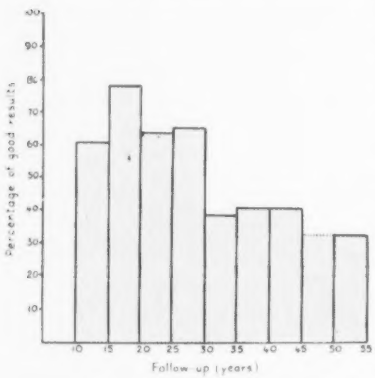

FIG. 4

Percentage of good results. Follow-up period dates from conclusion of treatment.

DISCUSSION AND CONCLUSIONS

In a series of 889 cases of congenital dislocation of the hip, treated over a fifty-year period corresponding roughly to the first half of the century, it was possible to assess the present state in 264. The sample is not an accurate one, since it presents features tending to give an unduly favourable picture. Of the cases examined a majority were first seen during the second half of the period, methods of treatment then being better than in the early days when all forms of treatment were still something of a novelty. In these cases, too, there had been less time for the occurrence of the deterioration of the hips which, as is well known, is inevitable. Furthermore, the average age at which patients were first seen was about four and a half years in the sample, whereas it was over seven years in the whole series. Both figures are a sad exposure of the delay in making the diagnosis which, for too long, has bedevilled the treatment of congenital dislocation of the hip in Great Britain.

Nevertheless we believe that the conclusions to be drawn from the examination of the sample are not wholly valueless, and indeed the favourable weighting of the results probably provides a better basis for comparison, in any future investigations, than that of the whole series which would include results dating from the time when the rational treatment of congenital dislocation was only just emerging.

Closed reduction was the method of choice, and such was the antipathy to other methods of treatment that manipulative reduction was attempted in patients well past infancy, and repeated with dogged persistence in cases when the initial attempt had been unsuccessful. Open reduction was usually employed with reluctance, and there was little enthusiasm for secondary corrective procedures such as the shelf operation and rotation osteotomy. Palliative operations such as the Lorenz osteotomy were indispensable in the treatment of a series of cases which included many patients well past the age when satisfactory reduction of the dislocation was possible. This is the general background, against which the following conclusions should be judged.

Closed reduction—There was reason for sober satisfaction with the results of closed reduction. In more than half the cases manipulation and plaster alone were employed. In no less than four-fifths of the unilateral cases so treated before the age of three, and in two-thirds of the bilateral cases the results were satisfactory. Between the ages of three and seven years the unilateral cases still gave almost equally good results, but there was a rapid falling off in the proportion of successes in the bilateral cases.

Immediate open reduction—Nine hips were so treated and the results were only moderate.

Manipulation followed by operation—Secondary operative procedures following manipulative reduction and plaster fixation were employed in twenty-three cases (twenty-six hips) and eleven hips were satisfactory. The shelf operation was the most satisfactory procedure especially when performed within two years from the initiation of treatment. Delayed open reduction would now stand self-condemned, for the decision that closed reduction has failed ought to be made within three months. However, it was formerly supposed that a spurious reduction, in which part of the capsule is caught between the joint surfaces, could ultimately succeed as a result of atrophy by compression of the interposed tissue; and we ourselves, like Severin (1950), have clear evidence from arthrograms that such a phenomenon sometimes occurs.

Closed reduction: late operation—There were patients in whom deterioration occurred some considerable time after closed reduction, the average interval between the initial treatment and the operation designed to relieve the disability being about twelve years. The effectiveness of these interventions, taken as a whole, was not remarkable; the secondary operation gave satisfaction in a little more than one-third of the cases.

No reduction attempted on account of advanced age: late operation—Under half of them were worth the attempt.

No treatment of any kind—There were patients who, in spite of completely neglected dislocations, were able to lead a moderately active life; in about half the cases function was good. The lesson to be learned from this and from the preceding group is that the unreduced dislocation is not a promising lesion for operative attack, at any rate with the procedures that have been described. The nature of the latter is discussed later.

Of the various operations employed some call for comment.

Open reduction—The results were bad; only four out of twenty were satisfactory.

Shelf operation—The shelf operation, on the other hand, gave encouraging results in about two-thirds of the thirty-six hips so treated and, it should be particularly remarked, the operation was effective in some children over the age of five. The notion must be abandoned that this is the upper age limit. As would be expected the best results were in those cases where the remodelling of the roof was anatomically accurate, but even a shelf that was too high was not invariably ineffective.

Rotation osteotomy—Rotation osteotomies presented a dismal picture; only four out of nine were effective. During the period with which we are concerned, the importance of anteversion as a cause of instability of the reduced hip was either denied or ignored. Re-examination of these cases, as well as the recent experience of one of us (H. J. S.) suggests that this deformity of the femur is, as many other observers have held, by no means negligible. Yet our surgical fathers could retort by pointing out that in these nine hips where an attempt was made to remedy the anteversion the results were hardly such as to justify the effort made.

Abduction, adduction and bifurcation osteotomies—The abduction, adduction and bifurcation osteotomies, a number of them required for the correction of the effects of injudicious treatment, do not inspire confidence. However, there is not enough evidence to warrant condemning them, though sufficient to encourage the search for better alternatives.

The effective life of the successfully treated hip is unquestionably the most important consideration of all. A good result is likely to last until sometime between the twenty-fifth and thirtieth years. Then, during the next decade, there is a rather more than even chance of the joint giving trouble. So far as we know, the survivors continue in fair comfort into middle life.

Osteoarthritis, so-called, occurs in half the cases, but disability was limited to rather more than half of this number.

Pain was a significant complaint in rather more than one-third of all patients re-examined, but sometimes occurred in the absence of a degenerative arthritis.

The significance of the C.E. angle of Wiberg is discussed, and some evidence is provided in favour of taking deliberate steps to improve the shape of a defective acetabular roof.

We are particularly indebted to Mrs Glen Haig, Medical Records Officer, Royal National Orthopaedic Hospital, and to her staff, for the great efforts they made to trace errant patients and for their help in the documentation of results. During eleven months of the period of this investigation one of us (G. M. M.) was in receipt of a research grant from the Institute of Orthopaedics.

We were greatly concerned about the statistical significance of the sample of 264 cases. The figures were thoroughly examined by Dr Ian Sutherland of the Department of Statistics, University of London, and they have been presented in a form which he approves. For this invaluable aid we are most grateful.

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OPEN REDUCTION IN CONGENITAL DISLOCATION OF THE HIP

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There is a wide divergence of opinion on the merits and demerits of open reduction of the congenitally dislocated hip. The protagonists of conservative treatment are at least as dogmatic as those in favour of open reduction and, in spite of the favourable results described by the latter, open reduction has never met with widespread enthusiasm and is usually reserved for those hips in which closed reduction has failed. The reasons for this seem to be threefold: firstly, there is a belief that open reduction damages the hip joint and causes growth disturbance in the upper femoral epiphysis and possibly stiffness as well; secondly, it is a big and, in a small child, dangerous operation; and thirdly, the cause of obstruction is not always obvious even when the hip is open. These objections will be dealt with later but some comment must be made on them now. In the small series of twenty-three cases described here in which open reduction has been carried out, there has been no instance of growth change in the epiphysis. The longest time since operation is three years, and the shortest time is six months. The operation to be described is simple and quick, being unassociated with shock, and there has never been any necessity for a transfusion or other form of resuscitation. The third argument is perhaps more valid according to reports in the literature. Leveuf (1948) described constriction of the capsule, adherence of the capsule to the head below or to the floor of the acetabulum, hypertrophy of ligamentum teres, fibro-fatty tissue, inverted limbus, among others as being the causes of obstruction, and many other authors have described similar findings. Doubt about the actual cause of obstruction has often led to an unnecessarily wide exposure of the joint to determine which factor is responsible in any particular instance.

On the other hand there seems to be little doubt that in the vast majority of congenitally dislocated hips there is some interposition of soft tissues at least in the early stages of the reduction whatever method is used to bring about the reduction. Opinions differ as to whether the soft tissue atrophies or is pushed out of the way by pressure of the head in the acetabulum, but the results of conservative treatment show that in about one-third of the hips treated the result is reasonably good, while in two-thirds it is unreasonably bad. This suggests that, although the obstruction is removed one way or another in a certain number of hips, yet in many, perhaps most, either it is incompletely removed or the damage done in the process leaves a permanently defective joint.

The value of gradual reduction on the "Wingfield" frame, and its advantages in reducing the incidence of osteochondrosis have been described by Scott,* but there seem still to be some missing factors which account for the remainder of indifferent results. This investigation has been carried out as a natural continuation of that work in an attempt to determine the nature of the obstruction that prevents immediate and complete reduction, and to devise an operation by which it can be removed with the least possible trauma.

NATURE OF THE OBSTRUCTION

The present report is confined to those cases of dislocation called by Haas "typical dislocations": dislocations associated with arthrogryposis seem to have a different pathology and are not considered here. The exploration of twenty-three hips with typical dislocations

* SCOTT, J. C.: Congenital Dislocation of the Hip. Page 372 of this number.

has led to the conclusion that an obstruction, if present, always has the same cause—namely an inverted limbus. Of the twenty-three hips opened it has been found in every one, and its removal has resulted in immediate, unresisted and complete reduction.

The limbus is a fibrocartilaginous lip to the acetabulum, which in the fresh specimen is pliable and may easily be inverted into the joint. It is largest posteriorly and postero-superiorly. Our knowledge of the pathological limbus is at first mainly obtained from arthrograms, in which the limbus can be seen turned into the joint (Severin 1950). When the joint is opened, the size, shape and position can readily be seen, and direct vision can give much more information how the obstruction is caused. Arthrographic appearances

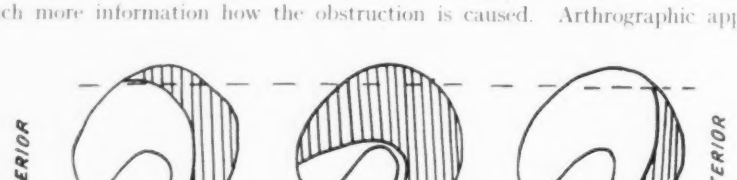

FIG. 1 FIG. 2 FIG. 3

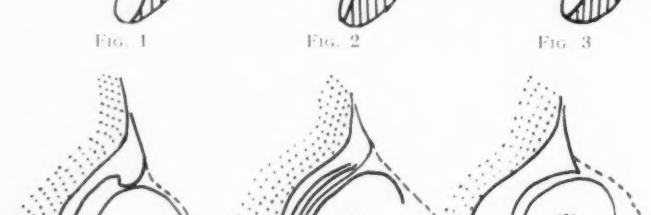

FIG. 4 FIG. 5 FIG. 6

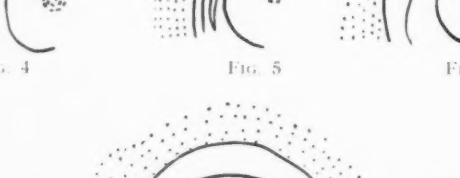

FIG. 7

Diagrams illustrating the size, position and appearance in arthrograms of the inverted limbus relative to the acetabulum. Figure 1 shows the usual size; Figures 2 and 3 show the extremes. In Figure 4 is seen the appearance in an arthrogram of a hip in which the limbus is inverted as in Figure 1; the head has been partially reduced. Figure 5 shows the arthrographic appearance of the hip represented in Figure 2; the limbus is so large that it almost forms a diaphragm. Figure 6 shows arthrographic appearance of the hip represented in Figure 3; the limbus cannot be seen; it lies posteriorly but the upper lip is deformed for the reason shown in Figure 7.

suggest that the limbus produces its obstruction by deformation of the upper lip of the acetabulum: what is not so readily appreciated but is obvious on direct vision inside the joint is that, though there is much variation in the extent of the limbus, it is largest posteriorly and is always to be found in that position, whereas the distance that it extends forwards along the upper lip is variable.

Figures 1 to 7 show diagrammatically the variations in size and appearance of the limbus which have been encountered. The first diagram (Fig. 1) shows the usual size; Figures 2 and 3 show the extremes. Figures 4 to 6 show the appearance as seen in the arthrogram of each type when the head has been reduced to the level of the acetabulum. Usually the

limbus is seen as a small fold turned into the joint (Fig. 4). This is sometimes mistaken for an hour-glass constriction (Fig. 8). If the limbus is very large and extends right across the joint almost like a diaphragm, it may be so large that it cannot readily be seen because the

FIG. 8

Arthrogram showing a medium sized inverted limbus giving an appearance often described as an hour-glass constriction of the capsule.

FIG. 9 FIG. 10

Figure 9.—Arthrogram showing a very large limbus forming almost a diaphragm. The femoral head is deformed by pressing on it. Figure 10.—Arthrogram of a hip in which a small limbus is present posteriorly. The upper lip is severely deformed by pressure of the femoral head.

head is flattening it into the depths of the joint (Fig. 9). When the limbus is small and lies posteriorly only, it cannot be seen in the arthrogram, but when the head is partly reduced we see the appearance shown in Figures 6 and 10. This is because the antero-

posterior diameter of the acetabulum has been reduced so that the head is "riding" on anterior, posterior and superior lips and is unable to sink into the depths of the joint (Fig. 7). The superior lip is deformed in consequence (Fig. 6) and the "reduction" is unstable. There can be little doubt that the limbus is large enough to cause an obstruction in this way. Figures 11 to 13 show three that have been excised.

With the assumption that the inverted limbus is the only major cause of obstruction to

FIG. 11

A medium sized limbus excised from the hip of a girl aged four years and eleven months.

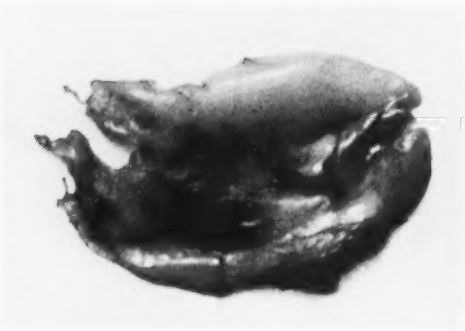

FIG. 12

FIG. 13

Figure 12—A large limbus excised from the hip of a child aged two years. The edges are thick, the centre thin, possibly from pressure of the head. Conservative treatment had been persisted with for six months before open reduction was undertaken (same scale as Figure 11). Figure 13—A small limbus excised from the hip of a child aged one year eight months (same scale as Figure 11).

reduction of the head into the acetabulum, it is obviously no very difficult matter to design an operation to remove the limbus without having to dislocate the joint or carry out any extensive dissection, and involving the least possible shock.

OPERATION

The operation is greatly facilitated if the hip is first partly reduced on a suitable frame until the femoral head lies opposite the acetabulum. Plain radiography will usually show

that it is standing out (Case 2, Fig. 17), and an arthrogram will reveal the obstructing limbus and "pooling" in the depths of the acetabulum (Case 2, Fig. 18).

The usual skin preparation is carried out with the patient on a frame, which is removed immediately before operation. On the operation table the legs are allowed to adduct and a sandbag is placed beneath the affected hip. The approach is a modification of the Smith-Petersen. A straight incision is made from below and medial to the anterior superior spine, obliquely upwards and backwards to the mid-point of the iliac crest. This is deepened, and the skin and fat are retracted upwards to expose the iliac crest, from which the abductor muscles are detached and reflected subperiosteally from the wing of the ilium until the capsule of the joint is exposed. This is facilitated by separating the tensor fasciae latae from the sartorius for about one inch.

The rectus with its reflected head is exposed and the edge clearly defined. It is usually possible to separate the rectus from the capsule with blunt dissection but occasionally a knife must be resorted to. It is never necessary to detach it from the anterior inferior spine. The rectus can then be lifted clear from the capsule with a retractor. A small, transverse incision is made in the capsule close to the acetabular lip, until the white, shining articular cartilage of the femoral head is visible and a little synovial fluid exudes. The incision is carried forwards transversely to the capsule deep to the rectus. This is done most easily and quickly with a Smillie cartilage knife. The incision is carried backwards to the posterior superior limit of the joint.

If the leg is now pulled downwards firmly, a gap of about one-quarter of an inch can be produced through which the inside of the joint can be seen. Sometimes the infolded limbus can be seen quite readily, but usually at first sight it is far from obvious and the acetabulum seems to be deep and well formed—quite different from the appearances on the radiograph. Examining the inside of the acetabulum with a probe will often disclose no abnormality, but, if a blunt hook is introduced into the joint, the tip of it can easily be slipped over the edge of the fold, which up to then has harmonised so well with the acetabular roof as to be "invisible." The tip of the hook can be forced through the base of the fold and the part of the fold lying in front can be separated from its periphery until the hook comes out. The free end is grasped with Kocher's forceps and drawn out of the joint, when the extent of the true roof of the acetabulum becomes visible and the fold is seen extending to the bottom of the acetabulum, attached at its periphery all the way. It is quite easily accessible and is removed with a pair of strong, curved scissors. With the fold removed the inside of the joint becomes much more readily visible and the whole of the acetabulum can be inspected without damage to the ligamentum teres or dislocation of the joint.

When the limb is fully rotated medially and abducted about 30 degrees the head sinks deeply into the acetabulum. The reduction will be stable, and so long as some degree of medial rotation is maintained, there is no danger of redislocation while the wound is being closed. It is unnecessary to suture the capsule, as the incision is closed with the hip medially rotated. Reattachment of the muscles to the iliac crest and closure of the skin are all that are required to complete the operation. A hip spica is applied with the hip fully rotated medially and abducted 30 degrees. More abduction than this may result in some degree of abduction contracture which may take some time to correct and delay early walking.

DISCUSSION

This paper is not concerned with the long-term result of the operation described, but is rather an attempt to demonstrate that the inverted limbus is a very important, if not the all-important, cause of failure to achieve immediate and complete reduction of a congenitally dislocated hip.

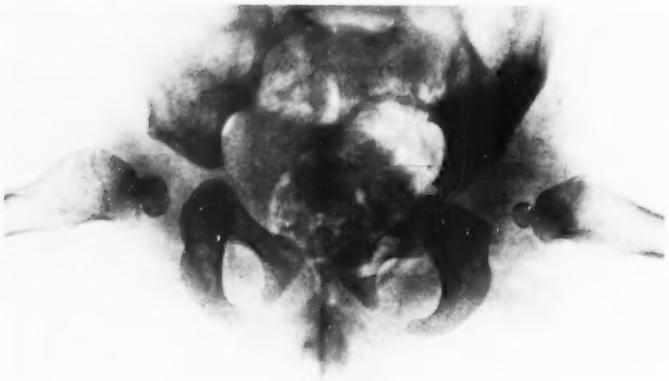

FIG. 14

Case I.—After seven weeks' reduction on a frame the femoral head is still standing out.

FIG. 15

Case I.—After excision of the limbus the femoral head is well and centrally placed.

FIG. 16

Case I.—Two and a half years after open reduction. The femoral head is standing out just a little, but the position has remained unaltered for one and a half years.

In this series of twenty-three open reductions of the hip, eighteen were done early—that is, before conservative measures had been tried for more than a few weeks. Five were done late, when conservative measures had failed and the hip had redislocated. Three of these have been combined with shelf operations. In all twenty-three hips the inverted limbus has been readily demonstrated. In twenty-one it was excised completely, and in two it was simply cut across transversely and left. In only one instance was any other procedure undertaken to obtain reduction, and in this a ruptured ligamentum teres was excised. In the others, when an enlarged ligamentum teres, a hypertrophied Haversian gland or other possible cause of obstruction was found, it was left untouched.

In all those in which the limbus was excised, reduction was complete on medial rotation and a little abduction, and, provided the medial rotation was maintained, remained stable. When the limbus was merely divided, reduction at the time was much less stable and radiographs showed a gradual reduction over some weeks. This suggests that, in these hips at any rate, the sole cause of obstruction was the infolded limbus.

The operation is not original but it is rather a combination of a number of operations described by others, based on the Smith-Petersen approach. The Smith-Petersen incision tends to leave an unsightly scar which may contract below the anterior superior spine, whereas the straight incision heals more satisfactorily. The incision is higher and more horizontal than that described by Cole (1935) because, unlike Cole's description, the basis of this operation is an exposure of the postero-superior aspect of the joint so that very little need be exposed anteriorly. Bleeding is thus reduced, the joint is not dislocated and the ligamentum teres when present is left untouched. The operation is quick, simple and free from shock, never taking more than thirty minutes and sometimes as little as fifteen. It has never been found necessary to use any form of resuscitation or transfusion.

The ages of the patients have been low compared with those described in other series, varying from eleven months to five years, most being about two years of age, and in no instance has an hour-glass constriction been found. No operative complications have been encountered. The first hip was operated on three years ago, the most recent in this series, six months. There has been one recurrent subluxation due to anteversion, correction of which has resulted in a nearly normal hip. There has been no growth change in the femoral epiphysis, and no hip which has been mobilised yet has regained less than 90 degrees of flexion. Many that have been free for more than a few months have regained full movements.

Because of the stability of the joint in medial rotation and the tendency to redislocation in lateral rotation it seems to be logical to follow the open reduction with a rotation osteotomy before mobilisation; that has usually been done.

ILLUSTRATIVE CASE REPORTS

Case 1—Girl aged one year nine months. Congenital dislocation of the left hip was reduced on a frame, but even after seven weeks in wide abduction the head was still standing out (Fig. 14). The arthrogram showed an obstructing limbus which was excised (Fig. 15); a spica was applied for three months, and thereafter Batchelor plasters were used for eight months; then a rotation osteotomy was done. Three years after admission this child has a full range of painless movement and complete stability (Fig. 16). She had also a subluxation of the right hip, which persisted after conservative treatment. It was corrected by a rotation osteotomy.

Case 2—Girl aged two years and four months when the dislocation was diagnosed. The dislocation was "reduced" on a frame but after five weeks the femoral head was still standing out (Figs. 17 and 18). Open reduction was undertaken, the limbus being excised (Fig. 19); a spica was applied for three months, followed by rotation osteotomy and a spica for six weeks, when free mobilisation was allowed. Now, a year later, she walks without a limp. The Trendelenberg is negative; there is full flexion, a normal arc of rotation but only 40 degrees of abduction. The result is marred by the coxa vara which has unfortunately been exaggerated by the osteotomy (Fig. 20).

Comment—These two cases have been chosen simply to illustrate the results after prolonged immobilisation and after immobilisation for a much shorter period. There is no reason yet to suppose that the result in the other cases will be any worse or any better than those shown.

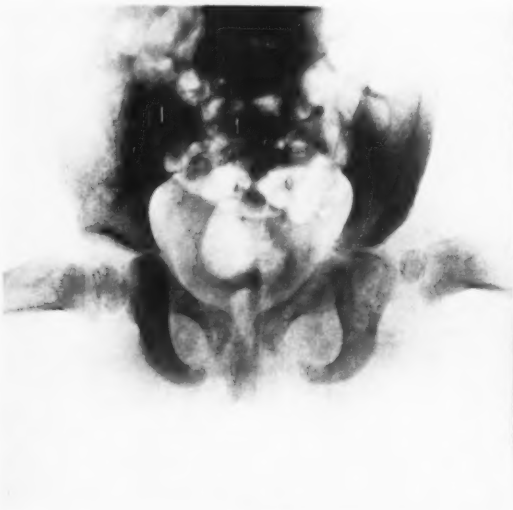

FIG. 17

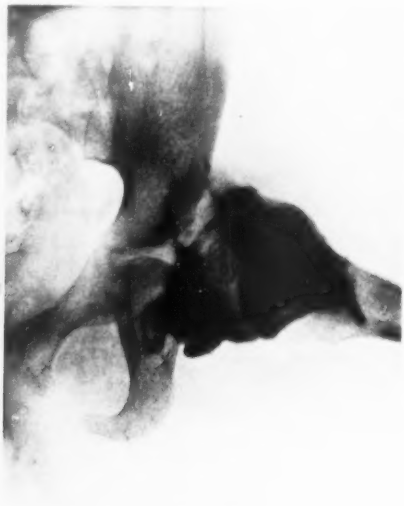

FIG. 18

Case 2. Figure 17.—After reduction on a frame for five weeks. The femoral head is opposite the acetabulum but is standing out. Figure 18.—The amount the head is standing out is well shown in this arthrogram. Note the pooling in the acetabulum and the compressed limbus turned into the joint.

FIG. 19

FIG. 20

Case 2. Figure 19.—After reduction the head has sunk into the acetabulum. Figure 20.—One year after operation the child has regained full movement except abduction which is only 40 degrees. The hip is stable, but the bony roof is still a little oblique though much better.

So far they are all running a similar course, some taking a little longer to achieve mobile joints than others, but the patients operated upon are taking no longer than others that have been treated conservatively.

Though it is far too early to be certain, there is at present no evidence to suggest that excision of the limbus causes any lasting damage to the joint and, as it is composed only of fibrocartilage, it will probably regenerate.

SUMMARY

1. It is suggested that the obstruction causing delayed reduction of the congenitally dislocated hip is the infolded limbus.
2. An operation is described by which the infolding limbus may be easily and safely removed.
3. The early results of the operation are reported.
4. The evidence for the original assumption is discussed.

I would like to express my thanks to Mr. J. C. Scott for his co-operation throughout this investigation, and to Dr. F. H. Kemp for his help and advice.

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FRAME REDUCTION IN CONGENITAL DISLOCATION OF THE HIP

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In congenital dislocation of the hip three essentials for good results are early diagnosis, early and accurate reduction without violence, and correction of associated deformity in femur and acetabulum if this is necessary for the maintenance of stable reduction. While no one disputes the importance of the first point, there is no unanimity about methods of obtaining the second, and the emphasis placed on the third varies greatly in different orthopaedic centres.

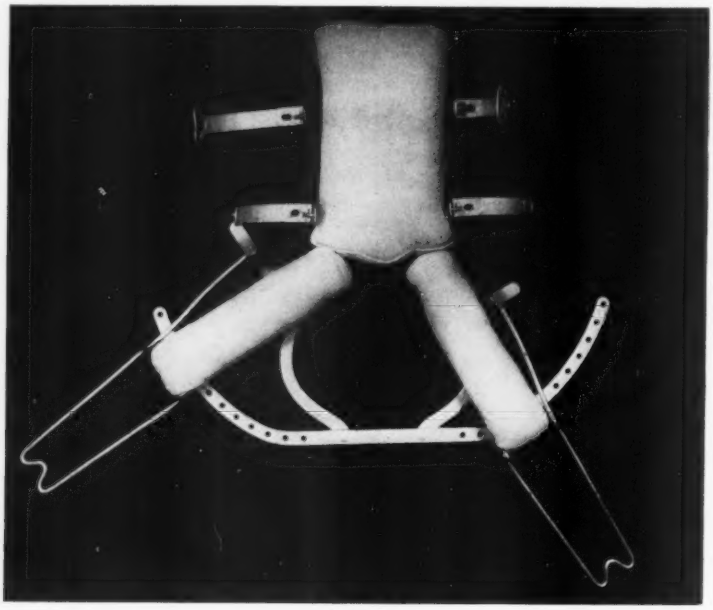

Fig. 1

Having organised an effective clinic system in our area, and so done what we could to promote early diagnosis, we began in 1935 under the stimulus of Mr G. R. Girdlestone to reconsider methods of reduction. This reconsideration was stimulated by various contemporary developments, namely: a clinical review of the patients with congenital dislocations of the hip treated at this hospital (unpublished); Farrell and Howorth's (1935) re-emphasis of the importance of dysplastic changes in the femoral head; Lambrinudi's insistence on the importance of anteversion of the femoral neck; and seeming general dissatisfaction with the results of treatment by the methods of closed reduction and immobilisation then practised.

The frame.—It was thought that the principle underlying the use of Putti's divaricator—a gradual reduction without the use of force—might be applied in children over twelve months old. The writings of Coonse and Stewart (1934) supported this view. No satisfactory apparatus for this purpose had been described, and the frame now known as the "Wingfield" frame was therefore designed (Fig. 1). The essential requirements to be met were: ease of continuous nursing, gradual abduction of both hips, and the application of traction to and across the

long axis of the limb. The frame is a modified Robert Jones abduction frame with hinges in the frame and saddle at the hip joints (Fig. 1). Fixed longitudinal traction is exerted by adhesive strapping extensions applied below the knee and fixed to the bows at the end of the frame, the pelvis being controlled by groin straps. The cross pull is applied by means of a wide band around the upper thigh; a cord to this is passed through a pulley on the opposite side of the frame and weights of up to two pounds are attached (Fig. 2).

METHOD OF REDUCTION

It was our practice in the early days simply to put the child on the frame, but since 1938, when we began doing arthrograms on all these patients, the following routine has evolved. After arthrography with about 7 cubic centimetres of diodone the child is put on the frame. The legs are gradually abducted, the rate depending on the age of the child (the average being 5 degrees per day); meanwhile a gentle longitudinal pull is maintained. When an angle of

FIG. 2

60 degrees of abduction has been reached the cross pull is applied and continued until reduction has been achieved, radiographs being taken at intervals of about seven days. If reduction seems satisfactory a second arthrogram is done, and the appropriate form of immobilisation applied. The abduction must be carried out slowly, and traction in either direction must not exceed two or three pounds. In all the uncomplicated dislocations in children up to five or six years of age it is possible by this means gradually to bring the head opposite the acetabulum. If there has been a failure of development of the hip, as in arthrogryposis multiplex congenita, the frame traction may have little or no influence on the position of the femoral head.

INCIDENCE OF SUCCESSFUL REDUCTION

Up to 1949, ninety-three patients were treated by this method, and in twenty the dislocation was bilateral. Eighty per cent were on the frame for less than two months. In ninety-eight hips satisfactory reduction was obtained; in fifteen it was necessary to resort to open reduction. Twenty-three other operations were done at a later stage, ten acetabulo-

plasties, twelve rotation osteotomies, and one combined acetabuloplasty and rotation osteotomy.

Of the ninety-seven hips of which a full series of radiographs is available, 8 per cent showed a moderate or severe degree of osteochondritis. In a comparable series of seventy-two hips treated by the Denucé method of reduction with immobilisation in abduction and medial rotation for similar periods, 26 per cent showed moderate or severe osteochondritis. We have now satisfied ourselves that gradual reduction does effectively reduce the incidence of osteochondritis. In those treated before the age of four, the incidence of moderate or severe changes has been reduced to less than 10 per cent. I doubt whether much further reduction will be possible. The incidence is of the same order as in untreated congenital dislocations of the hip.

OTHER FACTORS IN SUCCESSFUL TREATMENT

Since 1948 we have turned our attention to stability of the reduction, especially that obtained on the frame, and to the factors that might increase stability and allow the period of immobilisation to be decreased. The figures already given show that of the 113 hips studied fifteen required open reduction because no satisfactory reduction was obtained on the frame, and twenty-three required some secondary operation because the reduction was unstable. In other words, approximately 34 per cent could not be properly dealt with by this method alone, and in more than half of these the inherent instability was not recognised until too late. The worst results follow secondary subluxation or dislocation after the hip has been "reduced" and immobilised for many months, especially if the method of reduction has led to a severe degree of osteochondritis.

If the patients operated upon are excluded, stable reduction was produced as often as it is claimed for other methods of closed reduction. The clinical results will be assessed in detail later in relation to work now being carried out on the causes of failure of closed reduction.

We believe, then, that we can, using the frame, bring the head opposite the acetabulum, but that we cannot as yet recognise all those cases in which the reduction will not be stable, in spite of arthrograms and careful clinical estimation of the angle of anteversion. The radiographic appearances are often misleading, and those that look best do not always remain so.

SUMMARY AND CONCLUSIONS

The frame described has a place in the treatment of congenital dislocation of the hip especially if the diagnosis is not made until after the age of one year. Analysis of comparable series of hips reduced on the frame and by manipulation shows that dysplasia of the femoral head is decidedly commoner after the manipulative method.

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PRIMARY FUSION OF THE POSTERIOR SUBTALAR JOINT IN THE TREATMENT OF FRACTURES OF THE CALCANEUM

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The calcaneum is so shaped and so related to the wedge-shaped inferior surface of the talus that when it is fractured the major impact usually falls on the posterior facet of the subtalar joint. This fact is well known. Reference has often been made to it (Malgaigne 1847, Böhler 1935, Watson-Jones 1943) and its importance was again emphasised in the admirable study of fractures of the calcaneum by Essex-Lopresti (1952).

The ultimate function of the foot after the calcaneum has been fractured depends mainly upon two factors: 1) what happens to the subtalar joint; and 2) how much secondary stiffness

FIG. 1

FIG. 2

Figure 1—Crack fracture of the calcaneum seen in the axial view. There is no step; this fracture should be treated conservatively by control of the swelling and active exercise. Figure 2—Spontaneous fusion of left subtalar joint after fracture of the calcaneum which was untreated. The right foot was similar.

is allowed to develop in the foot. Osteoarthritis develops in a damaged and distorted subtalar joint and this complication is the main cause of late and prolonged disability. Another crippling complication is added if secondary stiffness is allowed to develop in the foot, as it will if the foot remains swollen or if it is immobilised in plaster after the injury. Treatment, therefore, should be governed by three considerations: the condition of the subtalar joint; the prompt control of swelling; and the maintenance of mobility of the foot.

TYPES OF INJURY TO THE SUBTALAR JOINT

When the fracture involves the subtalar joint there are three possibilities. First, the fracture may be only a crack without distortion of the joint surface or gross damage to the cartilage. If the calcaneum is protected from weight bearing until the bone heals, if swelling is controlled by bed rest, elevation and pressure bandaging, and if active exercises of the ankle and foot are practised from the beginning, there should not be any ultimate disability (Fig. 1).

Secondly, the joint surface may be so severely damaged that the subtalar joint fuses spontaneously. When this happens functional disability is often only slight. Figure 2 shows

CI

the left calcaneum of a man who sustained bilateral calcaneal fractures with other injuries in a fall from a height—injuries so severe that attention was focused on them and the fact that his heels were broken was not noticed. His feet were not treated. He came under my care eighteen months after the accident for the treatment of an ununited fracture of the humerus with a radial nerve palsy. His feet did not trouble him. He walked from four to five miles

FIG. 3

Routine lateral view of the heel. Displacement of the subtalar joint is evident. Primary fusion is indicated.

FIG. 4

FIG. 5

Figure 4—Axial view of the subtalar joint showing secondary displacement. Primary fusion is indicated.
Figure 5—Oblique view of subtalar joint. There is no secondary displacement. The injury should be treated conservatively. (Dr C. K. Warrick of Newcastle kindly lent this radiograph.)

and he stood throughout a football match. After successful treatment of his arm he is again working as a window cleaner. In spite of contrary opinions that have been expressed it is possible to work on ladders after fusion of the subtalar joint.

Thirdly, damage to and distortion of the joint surface of the calcaneum may be such that traumatic arthritis of the subtalar joint develops. The syndrome is well known. It is

characterised by pain in the heel on walking for a short distance even on a flat surface, sharp stabs of agonising pain on treading upon irregularities in the ground, and a commanding aching pain in the heel at the end of the day—" I don't know what to do with my foot in the evenings."

The patients in this last group are usually treated ultimately by subtalar fusion, often only after weeks or months of pain. This delay in definitive treatment is undesirable for three reasons: 1) disability is needlessly prolonged, perhaps even for months; 2) the patient suffers much avoidable pain; and 3) a " pain-pattern " may be developed in the cerebral cortex so that even successful subtalar fusion may fail to relieve the symptoms.

If the subtalar joint is distorted by the fracture it should be fused early. Fusion should be a part of the primary treatment, and should be undertaken as soon as the foot has recovered from the effects of the initial trauma. About three weeks from the time of injury has been found to be a suitable interval.

DIAGNOSIS

Distortion of the posterior articular facet of the calcaneum can often be recognised in the routine lateral view (Fig. 3). If it is not evident in this view an axial view (Fig. 4) or, better still, an oblique view (Fig. 5) (Anthonsen 1943, Bremner and Warrick 1950) must be studied before it is decided that there is not significant distortion of the joint surface. The term " significant " perhaps needs definition. The word distortion must be qualified. A fracture cannot involve a joint surface and not cause any distortion, but unless there is secondary displacement so that a step is formed the joint remains congruous when the fracture heals. The distinction is comparable to that which arises in the assessment of fractures of the head of the radius. The decision about the need for operation must depend on experience and the availability of radiographs of good quality taken in the correct axis.

TREATMENT

If there is significant distortion of the subtalar joint, operative fusion of the joint should be undertaken as a primary procedure. Fusion is indicated not because the displacement cannot be reduced—it can, as Gissane (1947) and Essex-Lopresti (1952) have shown—but because violence severe enough to displace the calcaneum has almost certainly caused irreparable damage to the articular cartilage. The programme therefore should be as follows. 1) Rest in bed with elevation of the foot in a pressure bandage usually for three weeks. Occasionally the post-traumatic swelling and ecchymosis subside rapidly so that fusion may be undertaken sooner, but not often. During this waiting period the toes, foot, and ankle should be exercised actively for five minutes every waking hour. 2) Posterior subtalar fusion by the posterior approach first described by Gallie (1943).

Operation—The patient is prone, the limb is exsanguinated and a pneumatic tourniquet is applied to the thigh. A four-inch incision is made along the lateral border of the tendo calcaneus. The pad of fibrous-fatty tissue which lies under the tendon should be excised—if it is simply incised it is difficult to retract and it gets in the way. A well defined layer of deep fascia covers the

FIG. 6

Anatomical detail of the posterior approach to the subtalar joint. Note that the posterior tibial neuro-vascular bundle is protected by the flexor hallucis longus muscle and tendon. Note also the situation of the lower end of the peroneal artery

muscle on the back of the tibia; when it is incised the fibres of the flexor hallucis longus are recognised by their medial obliquity. This muscle is retracted medially, and the posterior tibial neurovascular bundle is safe on the medial side of it and its tendon. The lower end of the peroneal artery lies close against the fibula. It is of variable size and because it may be large care should be taken to avoid it. The ankle joint is easily recognised—it can be identified beyond doubt by movement of the foot—and the subtalar joint is seen just below it covered by the posterior talo-fibular ligament (Fig. 6). The shape of the posterior aspect of the talus is not constant. It may be deep or shallow, the posterior process may be well developed and tongue-like, or it may be almost non-existent. It is therefore helpful to have a lateral radiograph of the foot on the viewing box in the operating theatre. If the joint cannot be seen with certainty it can be identified with a scalpel. The articular cartilage is excised from both surfaces with a thin-bladed osteotome as far forward as the sinus tarsi. The excision of cartilage may be awkward at first; it rapidly becomes easier as the joint is opened. The cavity is firmly packed with cancellous bone from the patient's iliac crest or from the bone bank. Only the skin has to be sutured and a pressure bandage is applied, *not a plaster*.

After-treatment.—This follows the same lines as the treatment during the period of pre-operative waiting and is directed to the same ends—the control of swelling and the maintenance of mobility. Active exercises are practised regularly from the first. The foot is elevated in a pressure bandage. As soon as the swelling is under control the patient may begin to get up with viscopaste or some similar supporting bandage on the foot. Regular non-weight-bearing exercises are continued throughout the convalescence; these movements do not interfere with fusion of the subtalar joint. Weight bearing is not allowed until there is radiographic evidence of fusion, usually at eight to ten weeks from operation.

TABLE I

DETAILS OF NINE PATIENTS WITH FRACTURES OF THE CALCANEUM TREATED BY POSTERIOR SUBTALAR FUSION (FRACTURES BILATERAL IN ONE CASE)

Case	Sex	Age (*years*)	Interval before operation	Return to work after operation (*months*)	Time of follow-up (*years*)	Occupation
1	M	17	1 year	4	1	Electrician
2	M	22	3 weeks	4	2	Labourer in bakehouse
3	M	29	4 weeks (bilateral)	11*	2	House-painter
4	M	41	3 weeks	6	3	Window-cleaner
5	M	35	4 weeks	4	3	Builder's labourer
6	M	56	3 weeks	7	4	Coal-trimmer
7	M	61	7 weeks	9	4	Street-hawker
8	F	48	3 weeks	4	5	Housewife
9	M	43	8 months	10*	5	Labourer in foundry

* Return to work delayed by compensation difficulties.

RESULTS

Fourteen patients with fractures of the calcaneum have been treated in this way. In four, the operation was less than one year before the review and one did not report for review; one patient had a bilateral injury. Therefore ten fractures of the calcaneum are studied.

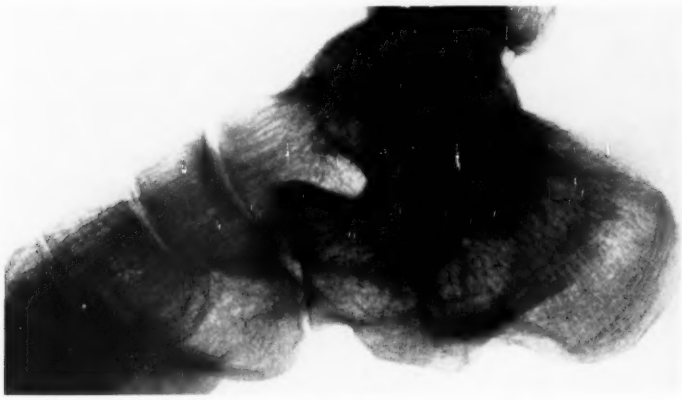

FIG. 7

Case 5—Three years after posterior subtalar arthrodesis.

FIG. 8

Case 7—Four years after posterior subtalar arthrodesis.

FIG. 9

Case 8—Five years after posterior subtalar arthrodesis.

In all, sound bony fusion of the subtalar joint was secured by the method described without post-operative plaster fixation. All returned to full work. None of the jobs was sedentary and some of them were heavy and rough. The average time between operation and return to work was six and a half months—if the two patients in whom the interval was longest and whose resumption of work was delayed by compensation difficulties are discounted, the average time was five and a half months. The results are summarised below and are tabulated in Table I. All were in full work at the time of review.

SUMMARISED CASE REPORTS

Case 1—Man aged seventeen. First seen one year after injury with typical subtalar arthritis syndrome and operated upon. Returned to work as electrician four months later—ladders and scaffolding. Review one year.

Case 2—Man aged twenty-two. Operation three weeks after injury. Returned to work as labourer in bakehouse four months after operation. Review two years.

Case 3—Man aged twenty-nine. Bilateral fractures. Operation four weeks after injury. Returned to work eleven months after operation (delayed by compensation). Full work as house-painter. Review two years.

Case 4—Man aged forty-one. Operation three weeks after injury. Returned to work as window-cleaner six months after operation. Review three years.

Case 5—Man aged thirty-five. Operation four weeks after injury. Returned to work as a builder's labourer four months after operation. Review three years (Fig. 7).

Case 6.—Man aged fifty-six. Operation three weeks after injury. Returned to work as a coal-trimmer seven months after operation (delayed by compensation). Review four years.

Case 7—Man aged sixty-one. Operation seven weeks after injury (delayed by dental sepsis). Was working as a labourer when he was injured; returned to work as a street-hawker—"Can do owt wi' t' foot." (May be translated, "does not consider that the condition of the foot constitutes a material disability," but should not be translated.) Review four years (Fig. 8).

Case 8—Woman aged forty-eight. Operation three weeks after injury. Returned to housework four months after operation. "Lives up fifty-six stairs—no disability." Review five years (Fig. 9).

Case 9—Man aged forty-three. Operation eight months after injury—when first seen. Returned to work as a labourer in a foundry ten months after operation (delayed by compensation). Review five years.

SUMMARY AND CONCLUSIONS

1. A small series of fractures of the calcaneum with distortion of the subtalar joint has been reviewed.

2. All were treated by subtalar fusion, in most as part of the primary treatment.

3. In all patients the subtalar joint fused by bone without post-operative plaster immobilisation.

4. Plaster immobilisation is not only unnecessary, it is undesirable.

5. Heavy work, including work on ladders and scaffolding, can be undertaken after subtalar fusion.

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SUPRACONDYLAR-Y FRACTURES OF THE HUMERUS

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The supracondylar-Y fracture of the humerus is one of those uncommon injuries whose treatment varies considerably from one clinic to another. It is caused by a heavy fall on the hand or point of the elbow, the olecranon being forced upwards as a wedge between the humeral condyles, prizing them apart and displacing them upwards and backwards. Displacement is considerable, and the fracture is unstable; the violence of the injury sometimes causes an associated vascular or nerve lesion. The fracture occurs usually in adolescent or in adult life.

It is a difficult fracture to treat, and the very diversity of views on the subject is an indication of the poor quality of the results often obtained. In the words of Watson-Jones (1943) " no injury of the elbow gives rise to more difficulty in treatment. It may be impossible to secure perfect replacement by manipulation and traction. Operative reduction is very difficult; it involves a free dissection of the triceps and capsule of the joint, and there is usually no natural stability of the fragments, so that reduction can only be maintained by screws and plates. Adhesion of the triceps, contraction of the capsule, avascular necrosis contribute to dense adhesion formation and permanent stiffness. Despite the perfect anatomical reposition which may have been secured the final range of movement is usually less satisfactory than after manipulation, even when manipulative reduction has been less accurate. Operative reduction is not justified by the results. Two alternatives are available: 1) To secure the best possible position by manipulation and traction. 2) In grossly comminuted fractures with irreparable joint injury to perform an immediate arthroplasty." Watson-Jones goes on to describe manipulative reduction followed by plaster immobilisation, a method which the author has found to be followed by considerable joint stiffness. Perhaps more commonly used is the so-called " bag of bones " technique, whereby the arm is supported in a collar and cuff, and immediate active movements practised. This is certainly a valuable method in the elderly, as a considerable range of movement may be obtained. The joint, however, is apt to be unstable and much power is lost, so that it cannot be said to lead to a satisfactory result in the younger patient. Late traumatic arthritis must not be forgotten; the elbow is a non-weight-bearing joint, but gross disorganisation of the joint surfaces does lead to arthritis in time.

If operative reduction is advocated the Campbell posterior approach is most favoured, with accurate fixation of all the main fragments by plates or multiple screws—a procedure calculated to lead to considerable limitation of movement. Surely a simpler approach to the treatment of this difficult injury is needed. The ordinary supracondylar fracture of the humerus is not difficult, and the Y-fracture can be converted into a supracondylar by the accurate reduction and fixation of the condylar fragments. Furthermore, the alignment of the intra-articular surfaces is thus restored, and good lasting function may be expected, provided the operative approach has done no harm. Any residual displacement between the two fixed condylar fragments and the shaft may be corrected by subsequent manipulation, and, even if it persists, will not have any great deleterious effect upon the ultimate function.

TECHNIQUE OF OPERATION

The key to the success of this simplified method of internal fixation lies in the exposure, and here the injury itself makes things easier for us. Provided the operation is undertaken within a reasonably short time of the accident, a vertical incision on either side of the elbow joint will lead one straight into the fracture haematoma. The flexor and extensor muscles

have been stripped from the surfaces of the humerus by the injury, and little further stripping is necessary; they can be retracted easily without further damage, and are thus preserved for early function. The joint as a rule is found widely open; if not, it is distended with blood, and an incision through the capsule gives free exposure. The approach is made from the side of the smaller condylar fragment; if this is on the medial side, as is the more usual, the ulnar

FIG. 1

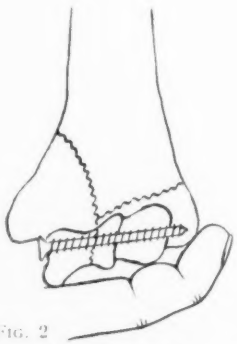

FIG. 2

Fixation of the condylar fragments of a Y-shaped supracondylar fracture with a screw. Thereafter the management is that of an uncomplicated supracondylar fracture.

nerve should be exposed early in the dissection, and may be transposed anteriorly if its course lies near the fracture site. When the fracture has been exposed, the index finger in the joint hooks the far condyle back into position against the near one (Figs. 1 and 2). The break between the two is sharp and clear cut, and it is not difficult to secure apposition by feel alone. While the finger holds the position a seven sixty-fourths inch drill is inserted through the cancellous core of the two condyles, and its position checked radiographically. If the position is satisfactory, the drill is replaced by a long screw, the finger being kept in position during the whole procedure (Fig. 2). When accurate apposition cannot be attained by manipulation, a seven sixty-fourths inch drill hole is made in the distal condylar fragment, and a nine sixty-fourths inch hole in the proximal; a screw is then passed through the proximal into the distal fragment, and the two approximated. The united condylar fragments are then manipulated, under direct vision, into as good a position as possible with the shaft, and the wound closed. External fixation is by pressure bandage alone, in moderate flexion, for three weeks, after which active movements are started as soon as the stability of the supracondylar element of the fracture allows.

FIG. 3

Case 1.—Showing full movement a year after operation.

The operation has been performed in six cases, five of which are reported in detail; the sixth was in a woman of sixty-five whose elbow stiffened remarkably quickly, for after three weeks she had virtually no movement; it would perhaps be better if operative reduction were reserved for adolescents and young adults, and the "bag of bones" technique used in the older patients.

CASE REPORTS

Case 1—A girl aged fifteen sustained a closed comminuted fracture of the lower end of the left humerus and a fracture of the lower end of the left radius as the result of a fall on to the hand

at gym. The elbow fracture was approached from the medial side, and a temporary screw was used to hold the upwardly displaced medial humeral fragment while the condyles were being fixed; it was then removed. Active movements were started at six weeks; the final range of elbow movement was full (Fig. 3), and the power normal.

Case 2—A woman aged thirty-five sustained a closed supracondylar Y fracture of the right humerus by falling from a horse (Fig. 4). There was extensive bruising around the joint, and a complete median nerve palsy on admission. At operation through a lateral approach, five hours after the accident, both the drill and the screw were placed rather high, but an adequate hold on both condylar fragments was obtained (Fig. 5). Active movements were begun five weeks later, and four months after the operation the range of elbow movement was from 160 to 60 degrees, with good muscle power. The median paralysis persisted; the nerve was eventually explored, and found embedded in scar tissue. After it had been freed, full recovery was obtained (Fig. 6).

FIG. 4
Case 2—Before treatment.

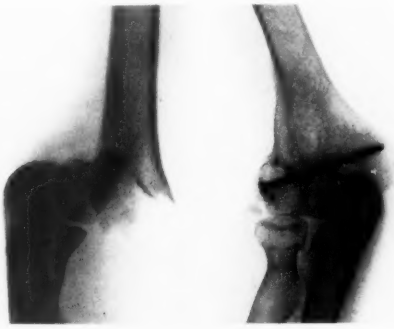

FIG. 5
Case 2—Fifteen months after operation.

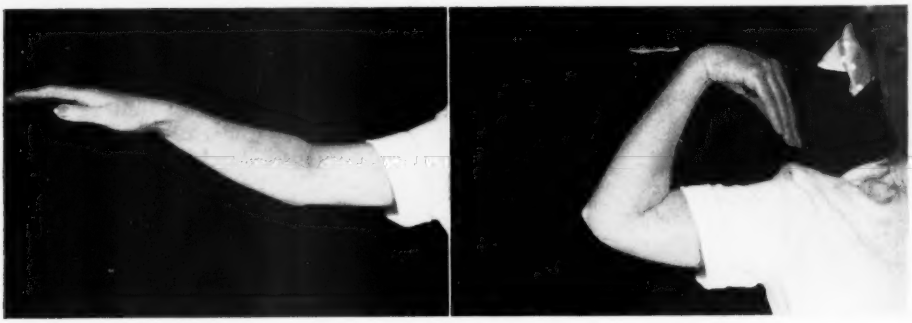

FIG. 6
Case 2—The range of elbow movement fifteen months after operation.

Case 3—A boy aged fifteen was admitted three days after a motor accident, having been treated in the first place in another hospital. He had sustained a comminuted compound fracture of the lower end of the left humerus, with a three-inch transverse wound posteriorly involving the triceps; the wound had been cleaned, packed with vaseline gauze and left open. It was felt that a stiff, possibly infected elbow joint was likely if it were left alone, and it was decided to attempt open reduction. Six days after the accident the posterior wound was sutured, and the condylar fragments fixed by a transverse screw, placed from the medial side. Active movements were begun four weeks later, and the fracture united with good joint alignment; there was, however, some forward displacement at the supracondylar site. His final range was from 145 to 50 degrees, which may be regarded as satisfactory, in view of the severity of his original injury. The power was normal, and he was free from pain.

Case 4—A girl aged eleven sustained a compound supracondylar-Y fracture of the right humerus, there being a small puncture wound at the back of the joint. In this case the fall was on to the hand, as is suggested by the upward displacement of the large fragment on the ulnar side (Fig. 7). This appears to be a comparatively common fracture pattern, and strong longitudinal traction on the limb is needed to obtain reduction. The condylar fragments were fixed with a screw (Fig. 8). Active movements were started six weeks after operation, and less than three months from the date of the accident she had an elbow range of from 170 to 60 degrees (Fig. 9). At this stage she left the country; she was still improving, and it may be supposed that her final range was greater.

FIG. 7
Case 4—Before treatment.

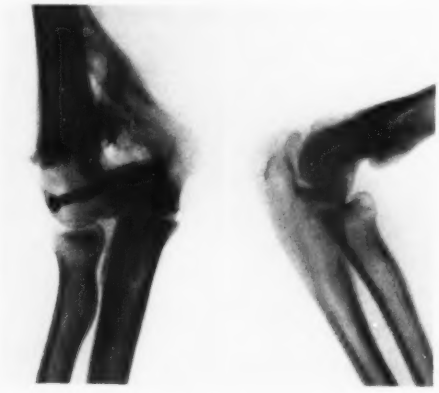

FIG. 8
Case 4—Ten weeks after operation.

FIG. 9
Case 4—Range of movement ten weeks after operation.

Case 5—A man aged forty-one fell from a ladder on to his outstretched left arm, sustaining a closed supracondylar-Y fracture of the left humerus and a fracture of the lower end of the radius; the upward displacement of the ulnar condylar fragment is clearly seen (Fig. 10). The condyles were fixed by a transverse screw placed from the medial side (Fig. 11); the ulnar nerve was found crossing the fracture site at the time of the operation, and was transposed anteriorly. Active movements were started at three and a half weeks, and the final range of movement was from 80 degrees to full extension (Fig. 12); the power was normal, and he had returned to his pre-accident work as an electro-plater.

DISCUSSION

It must be admitted that five cases provide slender evidence on which to base a claim for a new method of treatment. The supracondylar-Y fracture of the humerus is uncommon,

however, and a large series would be difficult to obtain. The accepted methods of treatment are not satisfactory. Manipulation is uncertain, and requires plaster fixation for retention of position, so that the final function is often poor. The " bag of bones " technique is useful in the elderly, but gives a weak unstable elbow, not acceptable to the young or to the manual worker. Accurate reconstruction is perhaps the least satisfactory method of all, for it entails wide exposure, with consequent damage to important muscle groups. It is felt that screw-fixation of the condylar fragments is reasonable, in that it takes care of the essential

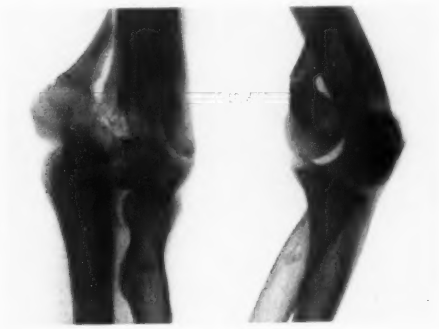

FIG. 10
Case 5.—Before treatment.

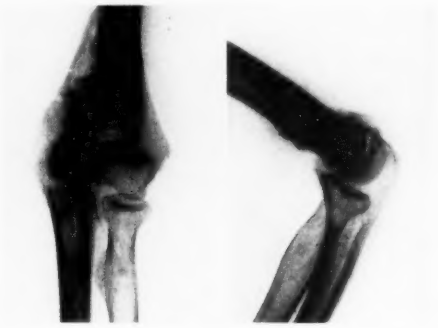

FIG. 11
Case 5.—Eight months after operation.

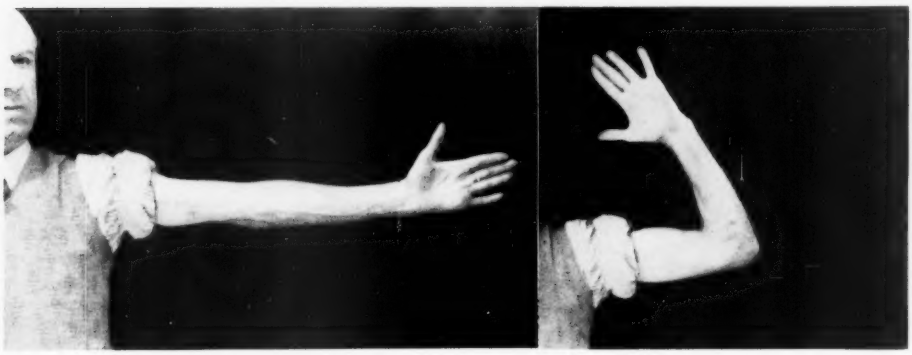

FIG. 12
Case 5.—Range of movement eight months after operation.

displacement and restores joint alignment, while the supracondylar element is dealt with by manipulation. The operation can be performed without damage to the important flexor and extensor muscle groups, and relatively early movements may be instituted without fear of redisplacement. One cannot expect a perfect result in this fracture, but by condylar fixation one should be able to rely on 60 degrees of movement, complete stability, and adequate muscle power.

I am indebted to Mr Gill of the Photographic Department of the Birmingham Accident Hospital for the preparation of the illustrations.

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REMODELLING OF THE HUMERUS AFTER SUPRACONDYLAR FRACTURES IN CHILDHOOD

C. G. Attenborough, London, England

In the treatment of a supracondylar fracture of the humerus in childhood the aim should be a perfect anatomical reposition of the fragments, attained by closed manipulation. If for any reason it is found impossible to achieve this ideal, there are two alternatives: open reduction, or immobilisation in the unreduced position. Open reduction is widely favoured at the present time. It is a common experience, however, that anatomical reduction gained by operation is followed by varying degrees of stiffness of the elbow, often severe and permanent.

It is the object of this paper to report a number of cases treated by the second alternative. Here the unreduced position is accepted, provided the alignment is good. The elbow is immobilised in plaster until the fracture is united, and remodelling of the humerus is allowed to proceed. The restoration towards normal anatomy is rapid and in some cases remarkable, and it is contended that the functional results are often better than those of open reduction.

It should be emphasised at the outset that it is not the object here to advocate non-reduction of all supracondylar fractures of the humerus. This method has been used only in those cases in which, for various reasons, an anatomical reduction could not be obtained by manipulation. It is only in children that remodelling can be relied upon for any marked anatomical improvement. All the patients in the following cases were under the age of ten years at the time of injury. The upper age limit has not been determined, but the degree of remodelling becomes progressively less in adolescence and is very limited in adults.

CASE REPORTS

Case 1—Boy aged seven years. Admitted with a supracondylar fracture of the left humerus, with medial displacement. Four attempts at reduction failed to improve the position materially (Fig. 1), and it was therefore accepted. Plaster immobilisation was continued for five weeks,

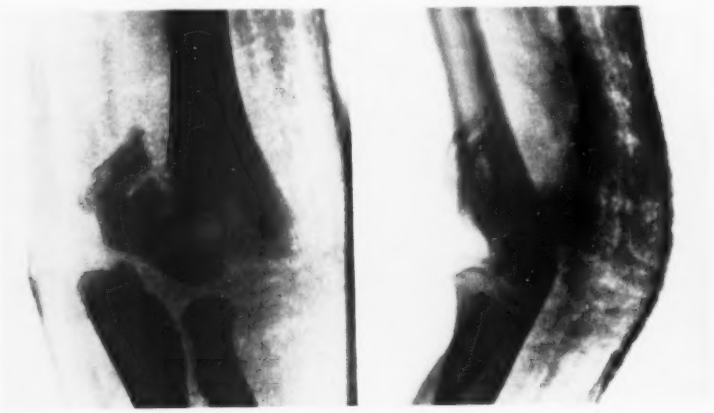

Fig. 1

Case 1—Position accepted after unsuccessful attempts at reduction.

after which radiographs showed marked new bone formation beneath the stripped periosteum on the medial and posterior aspects of the lower end of the humerus (Fig. 2). Six weeks later the range of movement was from 110 degrees to 180 degrees. A year later the range was from 75 degrees

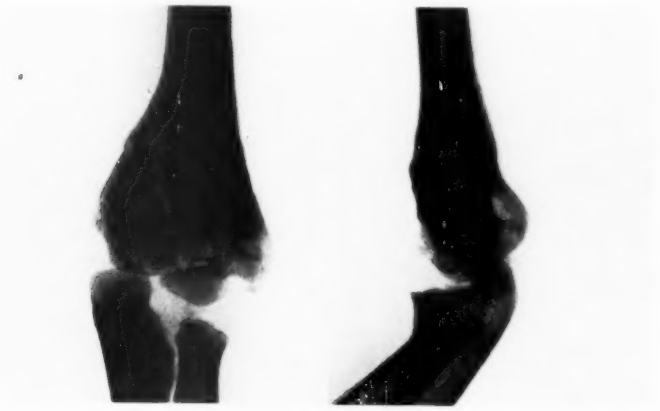

FIG. 2
Case 1—Five weeks later

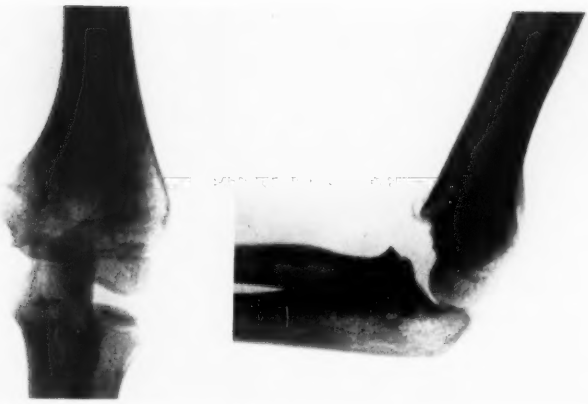

FIG. 3
Case 1—Two years after injury. Note marked remodelling

FIG. 4
Case 1—Showing range of elbow movement two and a quarter years after injury

to 190 degrees (5 degrees hyperextension was present in the normal elbow). Two years after the injury the anterior spur, though still present, was smaller and was relatively higher up the shaft of the humerus as growth proceeded at the lower humeral epiphysis (Fig. 3). The lateral spur had been completely absorbed. Four months later the left elbow range was from 65 degrees to 190 degrees (Fig. 4) and there was slight cubitus varus.

FIG. 5
Case 2—Initial radiograph.

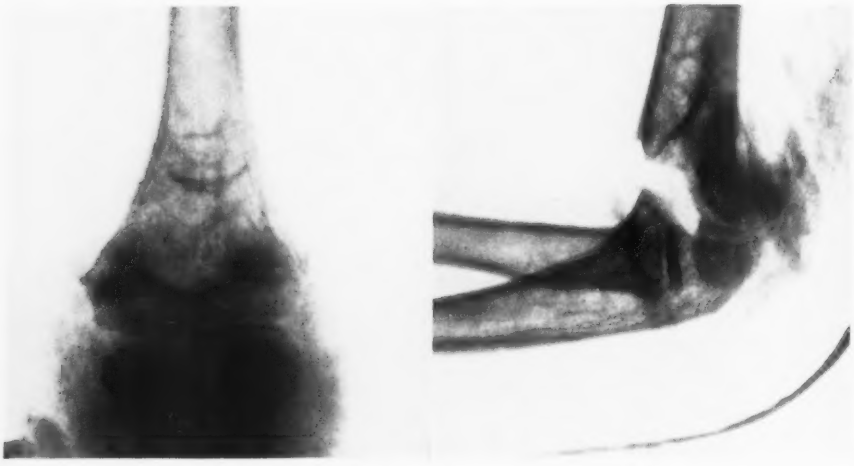

FIG. 6
Case 2—Position accepted after redisplacement of fragments.

Case 2—Boy aged nine years. Admitted with a supracondylar fracture of the left humerus (Fig. 5). Manipulation had failed to produce a satisfactory position. A good reduction was obtained three days later after a second manipulation. A plaster was applied with the elbow at a right angle. A few days later radiographs showed that the fragments had redisplaced (Fig. 6). Two further manipulations failed to improve the position and it was accepted. Radiographs thirteen days

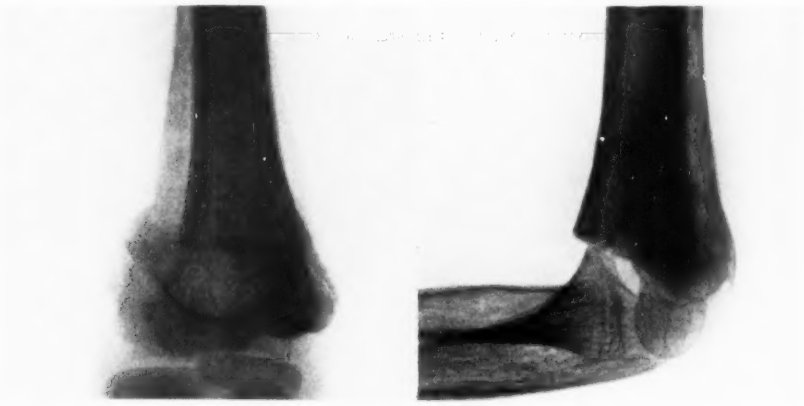

FIG. 7

Case 2.—Remodelling of humerus seven weeks after injury.

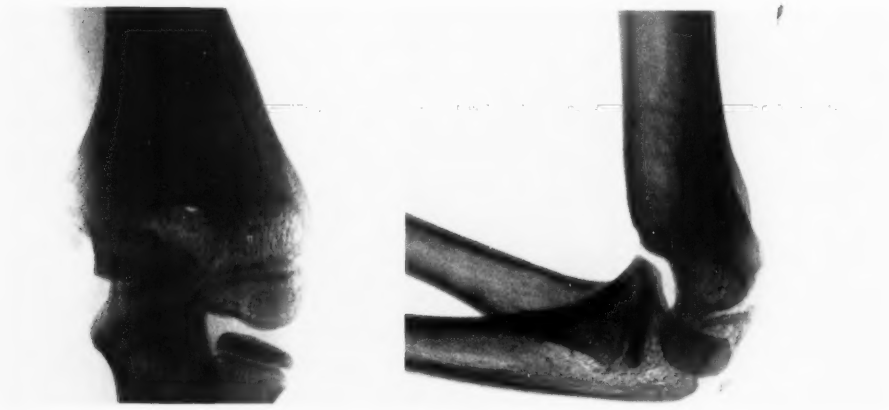

FIG. 8

Case 2.—Condition eighteen months after injury.

FIG. 9

Case 2.—Showing range of elbow movement eighteen months after injury.

after injury already showed subperiosteal new bone. The plaster was removed after seven weeks and radiographs showed well marked remodelling (Fig. 7). One month later the elbow movement was from 85 degrees to 100 degrees. Ten months after the injury it was from 80 degrees to 180 degrees. A year and a half after the injury radiographs showed absorption of projecting spurs, with an increasing distance between the residual anterior spur and the elbow as growth progressed

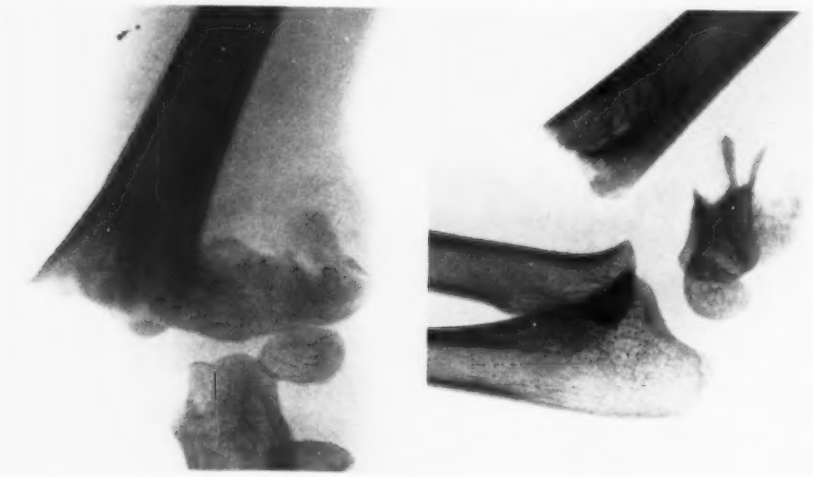

FIG. 10
Case 3.—Initial radiograph.

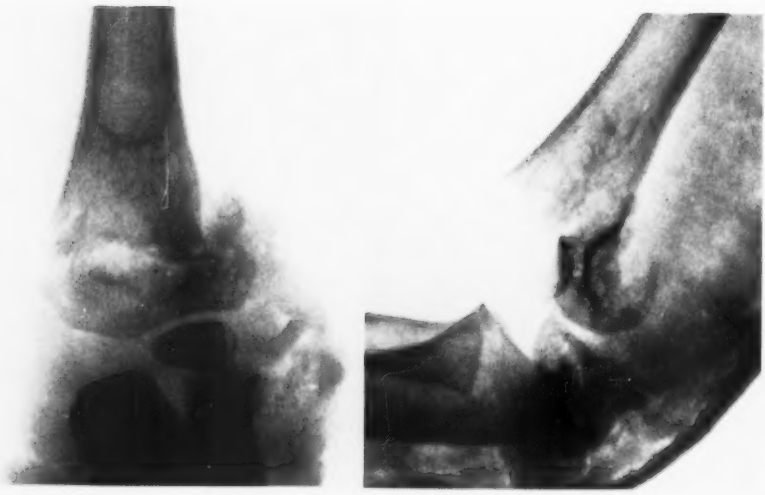

FIG. 11
Case 3.—Position accepted after unsuccessful attempts at reduction.

(Fig. 8). The elbow range was from 60 degrees to 180 degrees (Fig 9), and there was a cubitus varus of 15 degrees.

Case 3.—Boy aged five years. Admitted with a grossly displaced supracondylar fracture of the left humerus (Fig. 10). Two attempts at reduction failed to overcome the posterior displacement, but the alignment was good and the position was accepted (Fig. 11). Immobilisation in a plaster

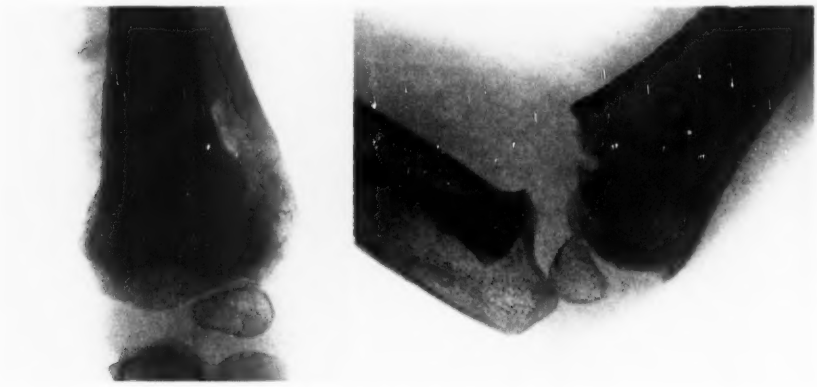

FIG. 12

Case 3.—Remodelling of humerus eight weeks after injury.

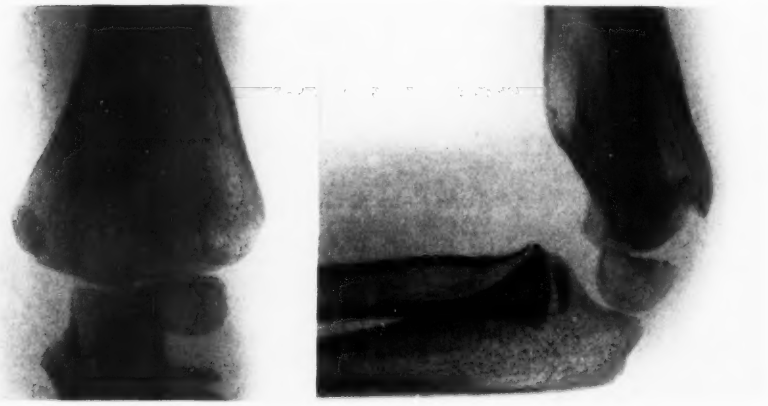

FIG. 13

Case 3.—Condition one and a half years after injury.

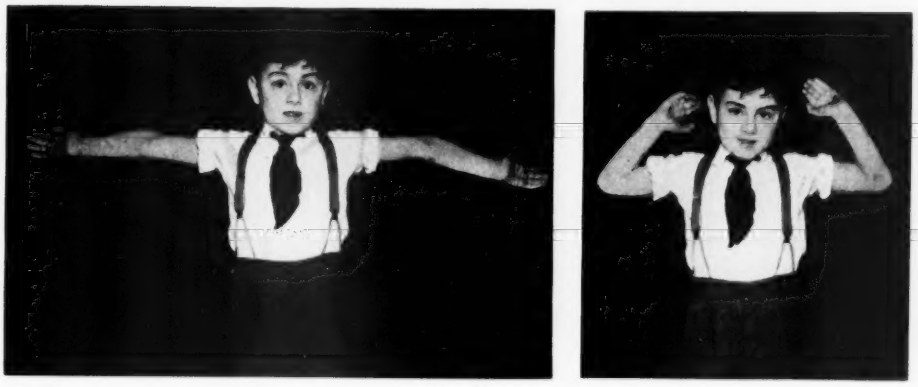

FIG. 14

Case 3.—Showing range of elbow movement one and a half years after injury.

cylinder with the elbow at a right angle was continued for eight weeks, after which radiographs showed marked remodelling (Fig. 12). One month later the range of elbow movement was from 90 degrees to 175 degrees. A year and a half after the injury radiographs showed considerable advancement of the remodelling process (Fig. 13). The elbow range was from 60 degrees to 190 degrees (10 degrees hyperextension, compared with 5 degrees in the right elbow) (Fig 14). There was cubitus varus of 5 degrees.

FIG. 15
Case 4—Initial radiograph.

FIG. 16
Case 4—Position accepted after redisplacement of the fragments.

Case 4—Boy aged seven years. Admitted with a supracondylar fracture of the right humerus. There was gross displacement posteriorly and laterally, and an incomplete median nerve palsy (Fig. 15). Manipulation failed to reduce the fracture and was repeated three days later. This time a good position was obtained, but, because of the marked swelling, it was found necessary to immobilise the elbow in a considerable amount of extension. Radiographs four days later showed redisplacement of the fracture (Fig. 16). The position was accepted and immobilisation

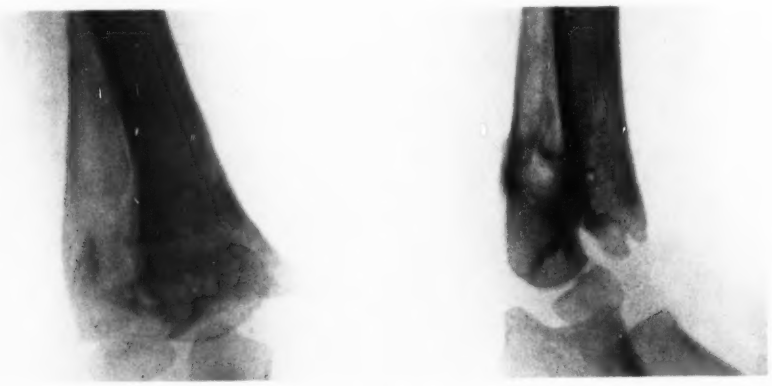

FIG. 17

Case 4.—Remodelling five weeks after injury.

FIG. 18

Case 4.—Condition seven months after injury.

FIG. 19

Case 4.—Showing range of elbow movement seven months after injury.

continued for five weeks. Radiographs then showed new bone formation beneath the stripped periosteum on the lateral and posterior aspects (Fig. 17). Five months later, further radiographs showed a remarkable degree of remodelling, with complete absorption of the medial spur, and a rapidly diminishing anterior projection (Fig. 18). The range of movement was from 45 degrees to 180 degrees (Fig. 19).

DISCUSSION

Supracondylar fractures of the humerus in childhood can be difficult injuries to treat. Few will deny that the standard method of treatment should be by closed manipulation and immobilisation in a plaster slab and collar-and-cuff sling. Later, when the swelling has subsided, a complete plaster cylinder may be used. The elbow should be in as much flexion as the swelling will allow, provided a strong radial pulse is retained. The optimum is about 45 degrees above the right angle, but it is frequently dangerous to flex the elbow to this extent, and a right-angled position, or even some degree of extension, may have to be accepted. If necessary, the manipulation may be repeated when the swelling has subsided (Watson-Jones 1943), but this should not be left later than five to seven days. The fracture rapidly becomes "sticky" and subperiosteal new bone formation may be seen radiographically within ten days or even earlier.

The difficulty arises when a satisfactory position cannot be obtained by manipulation; when redisplacement occurs despite repeated manipulations; or, rarely, when the fracture is first seen after an interval of several days since injury, still with its original displacement. The recent literature on the subject stresses the methods of operative treatment. Thus Swenson (1948) reported a series of patients treated by closed reduction and fixation by Kirschner wires inserted "blindly." Donchess (1949) advocated a posterior midline approach to the fracture site, and, after reduction under vision, fixation with Kirschner wires. Both these authors reported good final functional results. Sandegard (1943) was more guarded. While advocating operation for the "stubborn" cases, he stated that alteration of the carrying angle might occur in consequence, and that limitation of movement was common after operative reduction.

It has been a frequent finding that although an anatomical reduction may be obtained by operation a considerable measure of elbow stiffness often results, especially if metal or other foreign bodies are used in close proximity to the joint.

The alternative method of treatment is not new. Hey Groves (1916) commented upon the degree of remoulding which will take place in children. It seems, however, that this is in danger of being forgotten in an age of many operative procedures.

In the conservative treatment used in the cases reported here the fragments were left in the best position obtained by manipulation and the elbow was immobilised at a right angle in a plaster cylinder. In the earlier cases the immobilisation was continued for five weeks. In the light of experience, this time was extended to between six and eight weeks. Premature removal of the plaster seemed to result in a painful elbow, with marked spasm and subsequent slow progress. The longer period of immobilisation has been followed by a more rapid return of function.

Although quite severe posterior and lateral displacement may be accepted, the alignment must be good. Rotational deformity is seemingly not corrected by remodelling, except perhaps in infants. In two cases of this series slight backward tilting has resulted in hyperextension of the elbow, with more marked limitation of flexion than would otherwise be present. In three cases there is some cubitus varus, though this may have been caused partly by disturbance of growth at the lower humeral epiphysial line. In all cases the displacement, as opposed to rotation, of the distal fragment, has been smoothed off by the process of remodelling. Subperiosteal new bone formation is well marked, and projecting spurs are absorbed. The medial or lateral spur is absorbed particularly rapidly and the anterior spur more slowly. The residual anterior projection tends to become relatively higher

up the shaft of the humerus as growth proceeds, and causes less of a block to flexion of the elbow.

All these patients regained a full range of extension of the elbow within a few months of removal of the plaster. Flexion was regained rather more slowly and has continued to improve for a long time. In every case, the range of flexion is still increasing as the anterior spur diminishes.

SUMMARY

Four cases are shown to illustrate remodelling of the lower end of the humerus after supracondylar fractures with displacement in childhood. Remodelling is rapid and will restore almost normal anatomy and good function even with severely displaced fractures. The results are much better than in many cases treated by open reduction.

I wish to express my sincere thanks to Mr Cecil Flemming and Mr J. R. Armstrong for their guidance and encouragement, and for permission to publish these cases which were treated under their care. I wish also to thank Sir Reginald Watson-Jones for his helpful advice. For the clinical photography, my thanks are due to Mr R. F. Ruddick of the Photographic Department of the London Hospital.

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POSTERIOR PERIPHERAL DETACHMENT OF THE LATERAL CARTILAGE

E. A. Jack, Edinburgh, Scotland

This paper describes a lesion of the attachments of the lateral cartilage which, it is considered, deserves description as a distinct clinical and pathological entity. Although it seems probable that most surgeons concerned with knee joint surgery recognise the lesion, and, in fact, McMurray (1942) described it as " the commonest pathological condition of the external cartilage," it has not hitherto been given individual identity, but has been grouped indiscriminately from a clinical point of view, with tears in the substance of the cartilage.

The peripheral attachments of the lateral cartilage differ from those of the medial in that their continuity is broken by the passage of the femoral tendon of popliteus. This tendon enters the joint through a synovium-lined tunnel and lies in direct relationship with the rim of the lateral cartilage which it grooves obliquely. There is a hiatus in both superior and inferior coronary ligaments to permit its passage. The lesion consists of a tear of the synovial reflection and coronary ligaments backwards from the hiatus so that the posterior half of the intact cartilage loses its peripheral anchorage and is able to slip forwards into the joint (Fig. 1).

Interest in this condition was aroused eight years ago by the case of a soldier of twenty who complained of intermittent locking incidents in both knees, due clinically to lesions of the lateral cartilages. At operation the cartilages were found to be intact, but once dissection

Fig. 1
Diagram of the lesion.

had proceeded to the hiatus for the popliteus tendon, they could be pulled forwards easily and displaced completely across the centre of the joint, remaining attached only at the posterior horns. Symptoms dated from an occasion when he had been obliged to kneel crouched down, sitting on his heels, in a slit trench for half an hour during a bombing attack. Attempting to rise, he found both knees locked in flexion and he was unable to proceed until a companion had pulled them straight. Thereafter locking incidents recurred which he learnt to overcome himself by kicking the knees straight. Not long afterwards an almost identical case was encountered in a boy of sixteen who had hidden under a bed during a game of hide-

and-seek, and who was unable to rise when found until his sister had pulled his legs straight. Since then cases of a similar nature and with the same operative findings have cropped up with sufficient regularity to render the condition familiar.

CLINICAL FEATURES

The lesion tends to occur in relatively young patients and may be bilateral. The original incident that initiates the tear is not always so clear-cut as in the two cases quoted above, but there is commonly a story that the first attack of pain, situated in the postero-lateral aspect of the joint, developed after a period of relaxation with the knees fully flexed—for

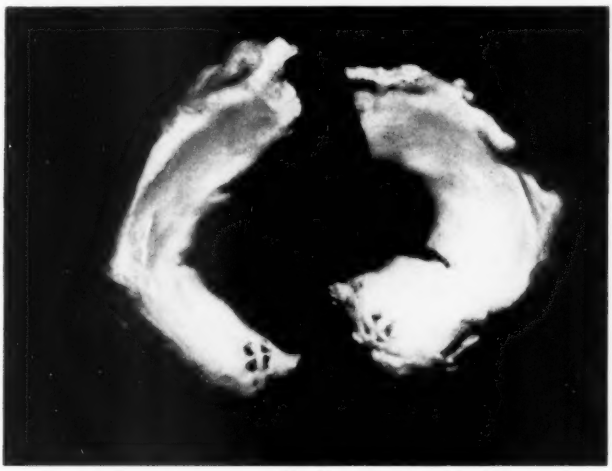

FIG. 2

Two lateral cartilages removed on the same day, the one on the right for cystic degeneration, the left an example of the lesion described. Compare the curvature of the posterior half of the cartilages and note on the left the absence of synovial reflections behind the popliteus hiatus and the rounding off of the posterior rim.

instance, after squatting on the heels for some time. It may be possible to identify in the story a medial rotation twist of the tibia. For a few days after this initial incident there is a mild synovitis with effusion, and a typical point of tenderness at the level of the cartilage behind the lateral ligament. Movements of the knee are normal and McMurray's sign is negative.

Thereafter the complaint may be of minor "catching" in the joint with transient postero-lateral pain. True locking occurs later as the tear extends. The knee locks in rather more flexion than is usual, often about ninety degrees, and release is easy and complete by a simple straight pull. In this respect the lesion differs in its behaviour from a tear in the substance of the cartilage.

PATHOLOGICAL ANATOMY

A characteristic feature at operation is the ease with which the cartilage is removed, the difficult part of the operation is already performed. Through a lateral parapatellar incision the anterior half of the cartilage looks normal and there may be a temptation to look elsewhere for the source of trouble. As dissection approaches the popliteus tendon it is common to find a small zone of hyperaemic reaction in the synovial membrane at the anterior edge of the hiatus. When the hiatus is reached the cartilage pulls forwards across the joint and division of the posterior horn releases it completely.

The normal curvature of the posterior half of the cartilage may be flattened by repeated forward displacement. The synovial reflection is found to be absent from the popliteus hiatus backwards, and the superior rim is rounded off by the persistent over-riding of the femoral condyle (Fig. 2).

MECHANISM OF INJURY

It seems reasonably certain that exaggerated flexion of the knee is the important element in the production of the lesion, combined possibly with medial rotation of the tibia. In flexion the condyle of the femur rolls back on the tibial plateau so that at the extreme range, it rests almost on the posterior edge. Medial rotation of the tibia tends to accentuate the position on the lateral side of the joint. A recent paper by Last (1950) described how the lateral cartilage normally escapes injury in this position. The medial half of the popliteus muscle is inserted by a fibrous aponeurosis directly into the posterior rim of the cartilage, and draws it back over the rounded edge of the tibial condyle as the knee flexes (Fig. 3). Last's description of this attachment and function of the popliteus has been verified in a series of dissections in freshly amputated limbs.

FIG. 3

Diagram of the popliteus control of the lateral cartilage. The femoral tendon of popliteus has been omitted and only the medial half of the muscle is represented.

The occurrence of bilateral lesions, and the youthful age at which they appear, may imply a structural predisposition to the lesion either in the form of laxity of ligaments or possibly anomalous insertion of the popliteus. Whatever the factor, the popliteus action seems to become temporarily ineffective and the cartilage slips forwards and swings medially on the ligaments of Wrisburg and Humphrey, so that it becomes trapped between the condyles. When straightening is attempted the cartilage is dragged farther into the joint and its peripheral attachments give way at the weak point at the edge of the popliteus hiatus. Subsequent episodes enlarge the rent until the popliteus attachment and all peripheral attachments behind the hiatus are torn away, and the posterior half of the cartilage is released from control.

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A CASE OF PROGRESSIVE JOINT DISORDERS CAUSED BY INSENSITIVITY TO PAIN

J. G. Petrie, Montreal, Canada

Rapidly progressive degeneration of joints in persons whose sensory function is impaired is well known in tabes dorsalis, syringomyelia, diabetic neuropathy and other diseases of the nervous system. The occurrence of such degeneration as a result of simple insensitivity to pain is less common.

CASE REPORT

A woman, born in 1926, has shown from birth a consistent lack of appreciation of pain. There is, and has been, no known similar disturbance in other members of her family. In 1948, at the age of twenty-two, she was investigated by Dr F. L. McNaughton at the Montreal Neurological Institute, but no evidence was found of any defect in her nervous system, and she was able to distinguish pinpricks for what they were, though to her they were quite painless. Temperature sense was normal, but extremes of temperature produced no pain.

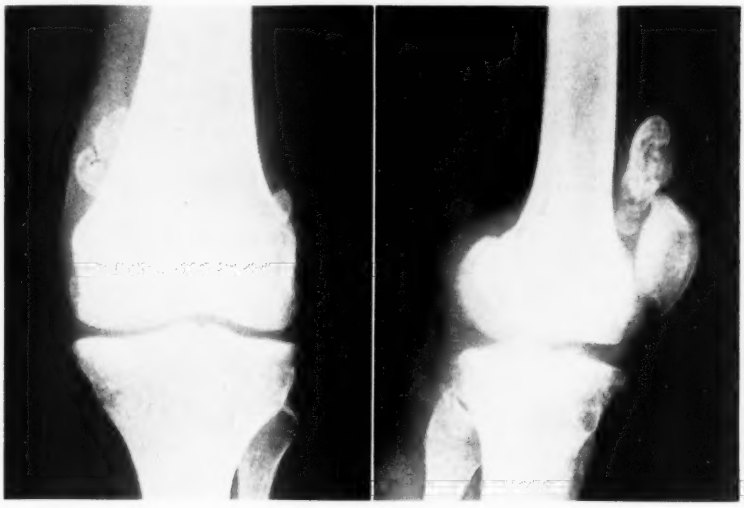

Fig. 1

Radiographs showing loose bodies in patient's left knee at age of seventeen

Stimuli that would normally produce pain evoked neither verbal report of pain, nor wincing, nor withdrawal of the part tested, and the blood pressure, pulse rate and respiratory rate were not affected. There was no evidence of psychological defect or of personality disorder. The electro-encephalograms were normal.

When twenty-one months old she had had a large painless abscess over her occiput. At three years of age she had had an equally painless osteomyelitis of her right calcaneum, and a pinch grafting operation for a painless burn which she had sustained when kneeling on a radiator. At the age of six she had acute pyelitis and osteomyelitis of the left femur, again without pain. At seventeen she noticed loose bodies, which were removed from her left knee (Fig. 1). At the same time, a thoraco-lumbar kyphosis was noticed, and radiographs

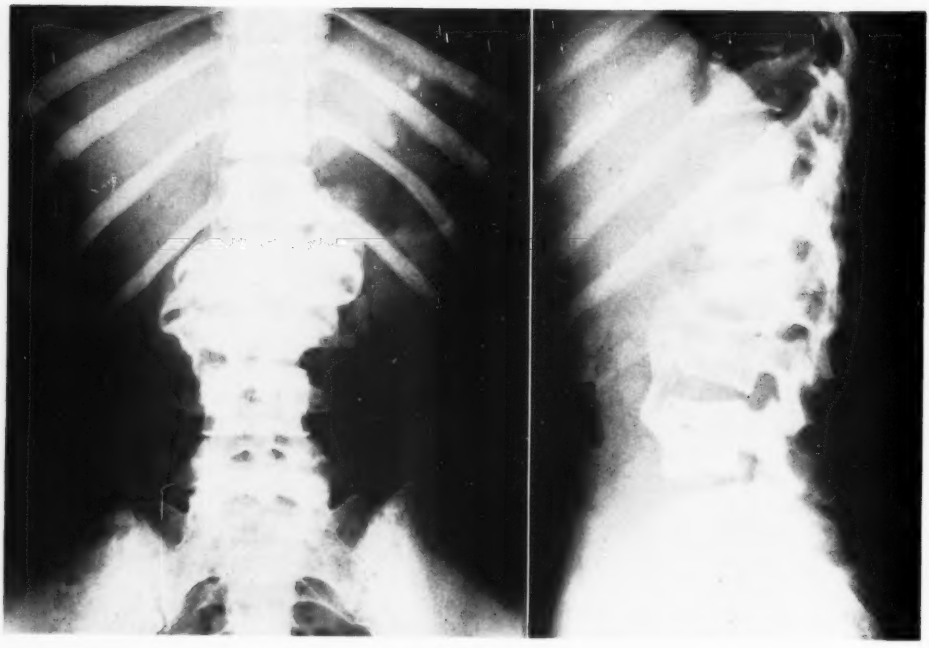

FIG. 2
Upper lumbar spine at age seventeen.

FIG. 3

FIG. 4

FIG. 5

Figure 3.—Right hip at age of twenty-two. Figure 4.—Right hip at age of twenty-three. Figure 5.—Appearance of the right hip after "shelf" operation.

of the spine showed some bone resorption in the upper lumbar bodies with condensation and osteophyte formation in the same region (Fig. 2). By that time her tongue was scarred and the soles of her feet bore numerous scars of painless injuries.

In 1948, at the age of twenty-two, she noticed "crunching" noises in her right hip and swelling in this region. Radiographs showed loss of substance in the acetabulum and in the femoral head (Fig. 3). Within four months she was limping. The hip then showed an abnormally free, painless range of movement in all directions, with grating. There was a considerable bony swelling palpable in Scarpa's triangle and the leg was two inches shortened. Her shoulders could now be subluxated and reduced at will. A year later, radiographs of the hip showed further destruction, with subluxation of the femoral head (Fig. 4). A "shelf" operation was undertaken, but it did not correct the limp.

FIG. 6

Lower thoracic spine (myelogram) at age twenty-five showing destructive lesion at T.10–11 and an obstruction to the flow of opaque fluid at the same level.

In 1951 her legs began suddenly giving way under her without warning, and pyramidal signs appeared with diminished sensation in all forms below the eighth-ninth thoracic level, and paralysis of the bladder sphincter. Radiographs now showed a destructive lesion at the T.10–11 interspace, with a soft-tissue mass around the involved vertebrae (Fig. 6). A lumbar myelogram showed a block at the tenth thoracic level, with a filling defect at the level of the tenth thoracic disc. *Operation* (right hemi-laminectomy, by W. V. Cone and J. G. Petrie) revealed compression of the cord at that level, with much granulation tissue of varying consistency in the extra-dural space. The cord was decompressed by removing bone and granulation tissue, and pulsation was restored in the theca. The spine was fused from T.8 to L.1. The histology of the granulation tissue revealed nothing specific. *Progress*—The patient made some improvement. Bladder function has returned, but she still has a severe degree of paraparesis.

DISCUSSION

Though some recent authors (Casagrande, Austin and Indeck 1951) have ignored loss of pain-sensation as an important factor in the cause of neuropathic joint disease, there is no doubt that this function is abnormal in the large majority of joints so affected. In this case changes identical with those of "Charcot's joints" in the knee, hip and spine occurred in a person with no other defect in her nervous functions until the spinal lesion itself produced a paraplegia. It seems probable that these joint changes were due solely to the lack of protection usually given by the sensation of pain.

The author is grateful to Dr F. L. McNaughton, chief of the Neurological Service, Montreal Neurological Institute, and to Dr W. H. Feindel of the Department of Neurology and Neurosurgery, McGill University and Montreal Neurological Institute, for their interest in this study.

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NOTE ON THE NERVE ENDINGS IN A SUBJECT WITH ARTHROPATHY AND CONGENITAL ABSENCE OF PAIN

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From the Department of Neurology and Neurosurgery of McGill University, and the Montreal Neurological Institute

Rare reports in the scientific literature have described subjects who were unreactive to painful stimuli. From some of these descriptions it is evident that the lack of pain sensibility was only one feature among a number of neurological defects. In other instances the question of an hysterical form of indifference to pain could not be entirely eliminated. But McMurray (1950) has recently investigated in great detail a young woman who had shown marked insensitivity to pain since birth, with no other demonstrable neurological or psychological stigmata. She gave no verbal report of painful feelings and failed to show either overt physical withdrawal or the changes in heart rate, blood pressure or respiratory rhythm such as are consistently produced by noxious stimuli in normal subjects.

From the orthopaedic point of view the particular interest in this patient, and in similar cases, lies in the involvement of bony structures, either from fractures which may go unheeded and subsequently become infected, or from degenerative changes about weight-bearing joints which may be related to the defective sensibility of the articular structures. The details of the changes in the skeletal tissues of this patient are described elsewhere in this number by Petrie.*

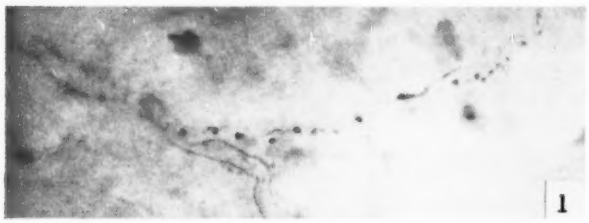
The present note is based upon the neuro-histological findings in biopsies taken at operation from the skin and underlying tissues about the hip joint. Although the material was limited, it has provided the first histological study in a case of this type. The observations may be of some value in determining the nature of the neural basis of this rare disorder and in defining the relationship to defective articular nerve supply in certain arthropathies.

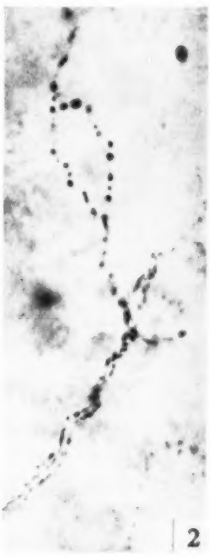
HISTOLOGICAL STUDY

Material and method—In the course of an operation on the right hip joint, Dr Gordon Petrie supplied small specimens of skin, superficial and deep fascia, periosteum, bone and cartilage, the latter three specimens being taken from the acetabular margin. The tissue was placed in 0·9 per cent saline and fifteen minutes later was immersed in 0·2 per cent methylene blue (Merck) made up in 0·9 per cent saline. Staining was controlled microscopically, the duration of immersion extending from fifteen to thirty minutes. The tissue was then washed in 0·9 per cent saline for fifteen minutes, kept in cold 8 per cent ammonium molybdate for four hours, then washed, dehydrated in alcohol, cleared in toluol and stored in methyl salicylate. This technique has the advantage of avoiding the necessity of sectioning, and makes it possible to keep the small bits of tissue intact, thus permitting a more adequate search for nerve fibres.

Observations—In the specimens of skin there were nerve bundles containing up to as many as seventy nerve fibres, including fibres of medium diameter and fine non-myelinated fibres. More superficially these bundles gave off smaller leashes of fibres which formed a sub-epithelial plexus (Fig. 1). Myelinated fibres could be traced to a point where they divided to give fine non-myelinated fibres, having a characteristic beaded appearance. These in turn each supplied a superficial network of free-ending naked terminals which stood out clearly against the pale-staining epithelium. The most superficial and distal fibrils of the network were usually single with loops or branching formations (Fig. 2). The deeper branches were multiple and

* PETRIE, J. G.: A Case of Progressive Joint Disorders Caused by Insensitivity to Pain, p. 399.





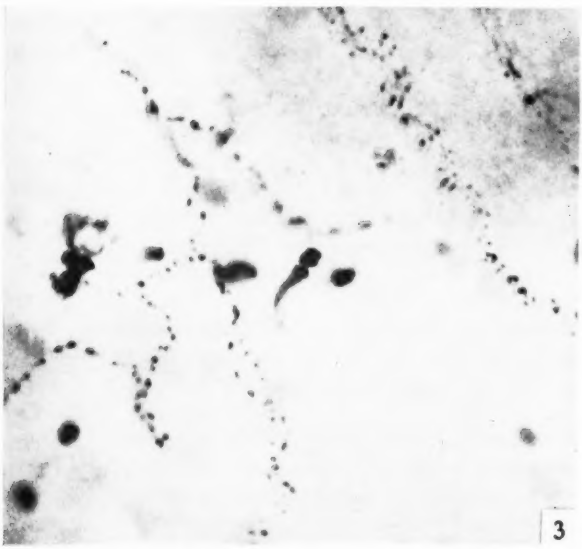


Figure 1—This shows a small subepithelial nerve bundle which includes fine myelinated and beaded non-myelinated nerve fibres (× 500). Figure 2—A loop formation of beaded fibres on a free nerve ending. In the lower left are seen intermingling beaded fibres (× 600). Figure 3—A superficial branching formation of fine naked nerve terminals. On the upper right is shown a bundle of intermingling fine nerve fibres which lie deeper under the epithelium (× 700). Figure 4—A fine nerve fibre which bifurcates to supply a free nerve terminal in periosteum (× 400). Figure 5—A small bundle of fine nerve fibres in periosteum (× 400).

intermingled with adjacent terminals from other fibres (Fig. 3). One end-organ was seen which was made up of a complex skein of terminals resembling a thermal receptor.

In periosteum no large nerve bundles were seen and the density of innervation was less than that of skin. Bundles containing up to four nerve fibres were present (Fig. 5). One fine fibre was seen bifurcating to supply beaded free terminals alongside a small blood vessel (Fig. 4), although no arborising networks were noted as in the skin.

In the specimens of superficial and deep fascia, bone and cartilage no nerve fibres were seen, but staining of these samples was unsuccessful. In view of the well known difficulty of staining nerve fibres and endings in peripheral tissues and the limited amount of material available these negative results may be discounted.

Bodian's silver proteinate impregnation of a small specimen of muscle showed normal striations, no increase of sarcolemmal nuclei and revealed no nervous structures.

Summary of histological findings—Normal nerve endings of the type subserving pain sensibility were found in biopsies of skin and periosteum taken from a patient with congenital absence of pain sense.

DISCUSSION

Free nerve terminals and pain—It has long been known that free nerve terminals are the only type present in the central part of the cornea (Ramón y Cajal 1909), from which an exquisitely painful sensation can be readily evoked. Free nerve endings also appear to form the exclusive innervation of teeth and of the tympanic membrane (Wilson 1911), and various kinds of stimulation applied to these structures give rise only to painful sensation. These observations and considerable additional evidence which has been reviewed in detail by Woollard, Weddell and Harpman (1940) leave little doubt that pain sensibility is subserved by free nerve endings. Sherrington (1940) pointed out how well adapted such endings are for pain sense, with their fine free terminals lying naked and unencapsulated among the cells of the tissue which they defend. The specific stimulus for pain organs is anything that does injury to the part which it reaches.

In the biopsy specimens of the present study, nerve fibres and free nerve endings are present and these show no morphological features that would distinguish them from the pain endings in normal subjects. They show the characteristic network of fine beaded endings with intermingling of the terminals from adjacent nerve fibres. There is no evidence of abnormality of the pattern, such as isolation of the free endings, which may be present in certain peripheral nerve disorders associated with over-reaction to painful stimulation (Weddell, Sinclair and Feindel 1948).

In the specimens of periosteum, the density of nerve fibres and endings was less than in the skin, but this is also the case in normal circumstances (Feindel, Weddell and Sinclair 1948) and, indeed, is probably an anatomical factor related to the poor localisation and vague quality of pain perceived from deep structures as compared with that aroused from skin. The relation of the free nerve terminals in the periosteum to small blood vessels does not necessarily indicate that they are vasomotor in function, for such endings may persist after autonomic denervation in animals. Moreover it was noted by Bazett and McGlone (1928) that pain can be evoked from needling blood vessels. It is known also from direct observation in patients under local anaesthesia that blood vessels of the dura mater (including the middle meningeal vessels and the venous sinuses) and the larger cerebral arteries may, in some subjects, be remarkably sensitive to painful stimulation, although other intracranial structures are almost wholly insensitive (Penfield and McNaughton 1940).

It should be emphasised that free nerve terminals, apparently histologically indistinguishable from " pain " endings, are also found in relation to glandular tissues (for example, the sebaceous glands of the skin), to fat cells and as accessory fibres to encapsulated sensory end-organs. Since the free nerve endings noted in the present study were not related to any

such structures, it seems justifiable to consider them as true pain endings. From the histological evidence available, it seems probable that the defect in the perception of pain and in the reflex protective effects of pain in this subject lies in central rather than in peripheral nervous structures. Study in similar rare cases might serve to define further the true neurological defect.

Pain sensibility of joints—The skeletal changes in this patient bring up the problem of the relationship of certain arthropathies to impairment of the innervation of articular structures. There seems little doubt that periarticular structures are pain-sensitive and the evidence for this has been critically reviewed by Gardner (1950). Observations on the sensitivity of synovial membrane, however, are contradictory. Davies (1945) readily aroused painful responses by pricking the membrane of the knee joint in a conscious patient. Kellgren and Samuel (1950), on the other hand, described the synovial membrane of the knee joint as a relatively insensitive structure with a few pain-sensitive spots surrounded by wide areas from which no sensation could be aroused. Certainly the rather vigorous forms of noxious stimuli they used seemed to arouse remarkably little response although it is of interest that injection of a small amount of 0·6 per cent saline did evoke a sensation of pain. An injection of this material serves as a somewhat diffuse stimulus, capable of affecting nerve bundles as well as endings, and also appears more effective than a punctate stimulus in arousing pain from the thinly disposed pattern of pain endings which seems to obtain in many deep tissues (Sinclair, Feindel, Weddell and Falconer 1948). In view of the paucity of pain endings demonstrated in synovial membrane, Gardner (1950) suggested that stimulation of the nerve fibres and endings accompanying blood vessels may be responsible for the painful responses from synovial tissue.

It seems clear therefore that joints are adequately provided with pain endings although the details of their density and distribution remain to be clarified. In addition, vasomotor, vasosensory, pressure and proprioceptive endings contribute to the innervation of joints.

Defective nerve supply and arthropathy—Experimental studies indicate that normal innervation is necessary for the maintenance of a joint that is undergoing the movement of ordinary use. Eloesser (1917) found that after section of the lumbo-dorsal roots in cats the animals that remained active developed changes in the joints of the limbs deprived of their afferent nerve pathways. He stressed the importance of anaesthesia and consequent trauma as significant factors. From the studies of Howell (1917) and of Tower (1937) it is evident that the growth and configuration of the bone itself is little affected by prolonged denervation consequent upon root section. Moreover, if the limb deprived of its sensory nerve supply is immobilised no joint changes are evident (Corbin and Hinsey 1939).

Corbin (1937) also noted that in animals allowed to move about after section of the afferent nerve supply of the lower limbs there was an increase in density and diameter of the femoral head with erosion of the hyaline cartilage from parts of the apposed joint surfaces. He concluded that the main factor was loss of proprioceptive sense, which allowed malposition and movement of the joint beyond its normal range, with consequent wear on articular surfaces unused to such stress.

No experimental studies appear to have been described in which only pain fibres to joints have been eliminated—as, for example, by spinothalamic tract section. Adult bones and joints appear to maintain their normal structure and function after autonomic denervation. There seems to be no good experimental evidence that loss of vegetative nerves to a joint can produce arthropathy. Indeed in some instances in which this has been claimed, the autonomic denervation has been anatomically incomplete, as pointed out by Gardner (1950).

Casagrande, Austin and Indeck (1951) contended that no joint changes followed neurectomy of the sensory nerves to the ankle joint in three patients. The effect of denervation in such instances is unfortunately assessed with some difficulty, since most neurectomies are performed when the joint has already undergone pathological changes.

Among neurological disorders tabes dorsalis and syringomyelia are characteristically associated with arthropathy. In tabes the disease produces extensive denervation similar to that in the experiments noted above, including loss of pain and profound impairment of proprioceptive sense from involvement of the sensory roots and posterior columns of the cord. The loss of deep (proprioceptive) sensation frees the joint from reflexes that would normally restrain it from a dangerous range of movement, while the loss of pain renders the patient unaware of any damage done to the joint, either by the abnormal range of mobility or by other means.

In syringomyelia, arthropathies develop in joints corresponding to segments of the spinal cord affected by the destructive cavitation. Fractures of bones of the analgesic limbs may go unnoticed. In spite of the more selective form of denervation, the incidence of arthropathy is reported as higher in syringomyelia than in tabes (Wilson 1940). Although some motor weakness may be present, the predominant defect is restricted to loss of pain sense (and usually of temperature sense) with little or no change in proprioceptive sensibility until later stages of the disease. The type of denervation is thus similar to that obtaining in the patient wholly insensitive to pain who had preservation of other modalities of cutaneous and deep sensibility.

Physical pain was described by Sherrington (1940) as a psychical adjunct of a protective reflex. In the present study there is strong evidence from McMurray's observations and from the clinical history as described by Petrie that the psychical aspects of pain were absent in this patient, as were the reflex responses to nociceptive stimuli. The changes in the skeletal structures might well be explained on the basis that the protective effects of pain were also lacking.

No doubt multiple factors are concerned in the development of joint changes after various forms of denervation. It seems clear, however, that joint changes can occur with loss of pain sensibility as the main feature. It seems reasonable to conclude that tissue damage from repeated wear and tear of ordinary activity, if unheralded because of impairment of pain sense, can lead to arthropathy. It is of interest that Charcot (1868), in his original clinical description of the joint changes in four patients with locomotor ataxia, emphasised their essentially painless nature.

SUMMARY AND CONCLUSIONS

1. A patient wholly insensitive to painful stimuli as judged by psychical, physical, reflex and autonomic responses, showed multiple arthropathies.

2. Biopsy specimens of skin and periosteum from the region of the hip joint showed free nerve terminals similar in morphology to endings considered to subserve pain in normal subjects. The abnormality related to defective pain sensation therefore appears not to be due to a defect in the peripheral nerve endings for pain, but to be located more centrally in the nervous system.

3. In this patient, and in some patients with syringomyelia, arthropathy is associated with selective impairment of pain sensibility of the involved joints. It appears that tissue damage from the wear and tear of normal activity of a joint, if this damage is unheralded because of impairment of pain sense, can lead to arthropathy.

4. It is noted that further experimental evidence is still required to elucidate the role of various modalities of innervation in the maintenance of normal structure and function of joints.

The author is grateful to the National Research Council of Canada for a graduate medical fellowship and to Dr F. L. McNaughton, Chief of Neurological Service, Montreal Neurological Institute, and to Dr G. Petrie, Surgeon-in-charge, Department of Orthopaedic Surgery, Royal Victoria Hospital, for their generous interest in this study.

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ARTHROPATHY OF THE ANKLE IN CONGENITAL INDIFFERENCE TO PAIN

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A boy born in December 1947 came under the care of Mr A. M. Hendry and myself shortly before his second birthday. He had bow legs, which had been treated elsewhere with night splints, under which sores had appeared rather readily. Splinting was therefore abandoned and the sores healed, while the legs, with no treatment at all, gradually became straighter. Just before his third birthday he twisted his right ankle. The joint swelled, and radiographs taken one week after the injury showed well marked osteochondritis of the talus (Fig. 1).

He was admitted to hospital for treatment of the ankle. It was then noticed that he had a habit of biting lumps of skin out of his fingers and that his tongue was very scarred. He was quickly shown to be quite insensitive to pain. He could be lifted by his hair.

The consulting neurologist to the Robert Jones and Agnes Hunt Hospital, Dr G. E. Smyth, found no sign of any other abnormality in the nervous system. He drew our attention to Ford's (1952) classical account of congenital indifference to pain, and close questioning of the mother established that this child's defective sensation was, in fact, lifelong.

It was decided to immobilise the ankle in plaster and, after a period of such fixation without bearing weight, he was allowed to walk in the plaster and to return home. Three days later he was seen by an after-care sister, who found his toes pink and warm and all satisfactory. About midnight that night he awoke, oddly enough complaining of pain in his right leg. He spent a restless night and at daybreak his mother recognised that his toes were discoloured. When he was brought to the hospital six hours later it was immediately obvious that a circulatory catastrophe had occurred. The plaster was immediately removed, and as it was removed a small plastic toy fell out from between the plaster and the upper part of the calf. It was shaped like a large comma, and there was an area of compression of similar shape and size in the skin just over the line of the popliteal artery (Figs. 3 and 4). The leg below the knee was swollen, cold, pulseless and paralysed. The skin of the foot and of the lower part of the leg was blue-black and apparently gangrenous (Fig. 5). There was no circulatory return on pressing the skin of the toes. The boy was seen by Sir Reginald Watson-Jones and Mr D. Ll. Griffiths about four hours after removal of the plaster, by which time the circulation had improved a little and the skin was warmer below the knee. Mr Griffiths injected 10 cubic centimetres of 2 per cent procaine around the right lumbar sympathetic cord. After about fifteen minutes the skin became warm down to the malleoli and a slow vascular return appeared on compressing the toes. Eventually a shallow skin slough separated from the dorsum of the foot and small areas of skin were lost from the tips of the four outer toes, but the lesions healed without skin grafting and without ischaemic contractures, though the toes were paralysed for nearly twelve weeks.

Since the vascular accident there has been evidence of increasing sensitivity to pain, but at the age of three years nine months he fractured his right clavicle without any pain. It united well. The ankle improved steadily in a weight-relieving caliper. Soon after his fourth birthday, when a hot-water bottle leaked he gave early warning of minor burns which resulted; but a few months later he developed a perforating ulcer of the right great toe. His sensitivity to pain is becoming progressively nearer to normal and he now feels the minor

FIG. 1

Right ankle at the age of three years, showing well marked osteochondritis of the talus.

FIG. 2

Three years later, after incomplete return of sensitivity to pain.

FIG. 3

FIG. 4

The cause of the vascular accident – a plastic toy pushed inside the plaster. Figure 3 shows the toy embedded in the plaster case. Figure 4 shows the position of the toy in relation to the child's limb. (The critical state of the circulation is not shown clearly in the photograph.)

FIG. 5

Condition of leg ten days after removal of the plaster.

injuries of a boy's life as well as any other child. The condition of the ankle has meanwhile improved steadily. (Fig. 2).

DISCUSSION

The most interesting feature of this case was the improvement in the condition of the ankle as sensitivity to pain developed. It is hoped that further recovery will occur and that other complications will be avoided. We can only guess why he felt the pain of his circulatory block, but it is possible that deep pain sensation was sufficiently acquired by the time of that incident to enable him to appreciate the pain of severe ischaemia.

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FAMILIAL HYPERPLASTIC CALLUS FORMATION

Case Followed for Twenty Years

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The case here recorded was first described (Hilton 1934) under the title "Familial Chondrodystrophy with Rheostosis Treated by X-ray Therapy." It is thought appropriate, in giving this up-to-date further account of the progress of the case, to substitute the description "hyperplastic callus," because the main features of the present case conform with those observed in hyperplastic callus formation in osteogenesis imperfecta. The present account records the progress of the patient over a period of twenty years.

CASE REPORT

Résumé of details previously recorded—A girl aged ten attended in 1932 with bilateral tumours of the thighs. The lower end of the left femur had become painful three weeks before, and soon after this a swelling had appeared. The only relevant history was of a fracture of the ankle at the age of nine but there had been no other fractures. The child was small and in poor condition, and the temperature was raised to 103 degrees Fahrenheit. The left thigh presented a large, hard, non-pulsatile swelling extending from the medial condyle upwards for three inches. Its most prominent part was tender. The right thigh showed a similar swelling beginning two inches above the medial condyle, rising sharply from the bone and extending upwards for a further two inches. Figure 1 illustrates the condition found on radiological examination of the left femur at that time. There is a mass of irregular ossification close to the medial surface of the lower end of the femur and, extending upwards from it, a soft-tissue shadow. The mid-part of the shaft of the femur is marked by hyperostosis. There is no evidence of any fracture, nor does the general appearance of the bone suggest osteogenesis imperfecta. Radiographs of the right femur showed similar changes. Examination of the rest of the skeleton revealed hyperostotic ridges on both humeri, the forearm bones, the left fibula and some of the metacarpals and metatarsals. The forearm bones showed distortion of shape, and the head of each radius was dislocated forwards and upwards.

A biopsy was performed on the left femur. Figure 2 illustrates the histological appearance. The central part of the section shows very cellular chondroid tissue and in the lower part there is chondro-osteoid tissue. Subsequently, the swelling increased in size, and Figure 3 illustrates the appearance between two and three months after the onset of symptoms.

Family history (in 1934)—The father was said to be normal but there had been no opportunity of examining him. The mother, aged thirty-one, was small and under-developed but otherwise healthy. The radiograph of her femur revealed a hyperostotic ridge and her forearms showed dislocations of the upper ends of the radii as in the daughter. One brother, aged two, had been examined radiologically and found normal. One maternal aunt, aged thirty-six, resembled the patient's mother in having a hyperostotic ridge along the femur and dislocation of the head of the radius. The second maternal aunt, aged twenty-four, who was severely deformed, was found to have changes in the bones like those in the patient but of a more pronounced character. The long bones were bowed and expanded, the cortices were thin, and numerous hyperostotic ridges were present.

FIG. 1

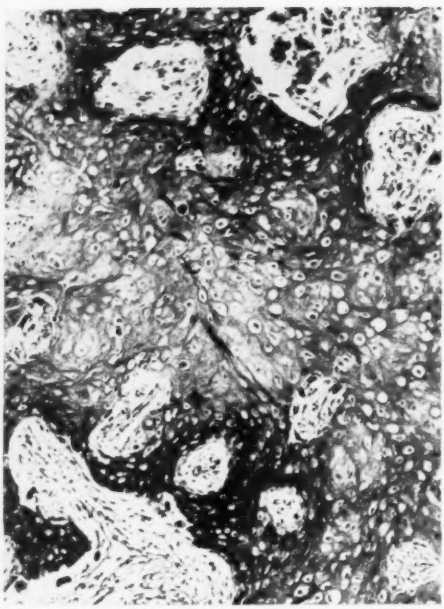

FIG. 2

Figure 1—The left femur three weeks after the onset of symptoms in 1932. Figure 2—Histological section of part of the ossifying callus. There is highly cellular chondroid tissue and in the lower part of the figure some chondro-osteoid tissue.

FIG. 3

FIG. 4

Figure 3—The left femur between two and three months after the onset of symptoms, showing typical hyperplastic callus now ossified. Figure 4—The left femur eighteen months after the onset of symptoms. The greater part of the ossified callus has now been absorbed but there is a " sleeve " of new bone enclosing the shaft of the femur.

FIG. 5

The pelvis and upper end of each femur in 1937. There is bilateral protrusio acetabuli and hyperostotic ridges are to be seen on each femur.

FIG. 6

FIG. 7

Figure 6—Left forearm in 1943. Note the typical appearance of the upper forearm and elbows with dislocation and distortion of the upper end of the radius. There is a small recent formation of new bone on the medial surface of the ulna. Figure 7—A recent radiograph of the right forearm bones showing hyperostoses on the interosseous borders with ossification of the interosseous membrane and synostosis.

Treatment—Treatment by radiotherapy to the lower ends of both femora was undertaken. It appeared to lead to symptomatic improvement, and coincided with definition and hardening of the mass of "callus" and subsidence of pain and tenderness. (Other cases reported in the literature have followed the same cycle of changes without x-ray treatment.)

Further progress—Since 1932 there have been many subsequent painful swellings in relation to the cortices of other bones, each accompanied by similar radiographic appearances. One year after the patient was first seen a painful lump developed over the right fibula and ossified. Figure 4 shows the radiographic appearance of the left femur eighteen months after the onset of symptoms. The greater part of the new bone formation has disappeared. The shadow of the shaft of the femur is now enclosed by a sheath of bone resembling periosteal new bone.

FIG. 8

A recent radiograph of the leg bones.

In 1937, five years after the onset, fringes of new bone were found round the lower margin of the pubic ramus and ischial tuberosity. Figure 5 shows distortion of the upper end of each femur and bilateral protrusio acetabuli; hyperostotic ridges are to be seen on each femur.

In 1942 a lump appeared over the right humerus and was shown radiographically as a soft structureless shadow which subsequently became absorbed but for some residual thickening of the humerus. Figure 6 illustrates the radiographic appearance of the left forearm in 1943. The distortion and dislocation of the head of the radius are well shown and there are marked hyperostotic ridges on the interosseous borders of the upper ends of each forearm bone. There is a small recent patch of new bone on the medial side of the upper end of the ulna. Figure 7 is a recent radiograph of the right forearm showing the well marked hyperostotic ridges on the radius and ulna and apparent synostosis of the upper ends of these bones. Figure 8 shows a recent radiograph of the tibiae and fibulae of both legs. There is distortion of the shaft of the radius with marked hyperostotic ridging of the bone and synostosis of the lower ends of the tibia and fibula in each leg. Figure 9 is a photograph of the patient and her mother taken recently.

DISCUSSION

Battle and Shattock (1908) published in the Proceedings of the Royal Society of Medicine an account of a boy aged four who was brought to St Thomas's Hospital for a tumour of the left femur. He broke his femur in April 1901. The limb was put in plaster-of-paris; this was removed at the end of three weeks on account of excessive swelling of the thigh, which was said to have reached three times the size of the other one. The femur united and the patient was able to walk. The swelling was said to be diminishing. On examination, the left femur was found to be the seat of a hard fusiform swelling. There was no pain or tenderness and the child appeared to be in good health. A radiographic diagnosis of periosteal sarcoma was made and the affected limb was amputated through the hip joint in November 1901. It is recorded as a remarkable fact that a few months later the boy's mother developed a tumour of her right femur for which amputation of the thigh was performed in 1903, and it was further recorded that a younger brother of the boy, aged two and a half, was admitted to the Rochester Hospital in 1907 with a fracture of the right femur complicated by the development of an extensive tumour of the thigh. A piece of the growth was removed for microscopic examination, the report being that it consisted of well formed bone with connective tissue and cartilage in process of ossification.

FIG. 9

A recent photograph of the patient and her mother.

The boy who had first been seen at St Thomas's Hospital and whose leg had been mistakenly amputated returned in June 1903 on account of a swelling of the femur in the remaining leg. There was no fracture. At the time it was recorded as a sarcoma of the same kind as the original growth on the other femur. When he was later readmitted to Hospital in March 1907, it was reported that he had developed a further tumour, this time on his right shin after a fall. It was noted that the head was large and wide across the frontal region and that the forearms were deformed. Radiographs of the forearm showed hyperostotic ridges on the interosseous borders like those noted in the present case. This remarkable case of Battle appears to be the first recorded instance of hyperplastic callus formation in association with some general bone disorder allied to osteogenesis imperfecta.

More recently, Brailsford (1943) and Fairbank and Baker (1948) have described similar cases. That here recorded was included by Fairbank in his description of eight cases, with the comment that the bony thickenings and recurrent bony swellings were typical of the condition under review but that there was no evidence of osteogenesis imperfecta in the usual sense of the term. Fairbank regards the typical features as: 1) The formation of a large mass of intensely calcified local callus adjacent to the bone affected; 2) the absence sometimes of a recognisable recent fracture; 3) the tendency of the callus, when it ossifies, to be permanent and incorporated into the structure of the affected bone; 4) the formation of bony excrescences or hyperostoses on the shafts of the long bones, particularly on the interosseous borders, a change most likely to affect the radius and ulna; 5) usually stunting and invariably bony deformities; bilateral dislocation of the heads of the radii were noted in three cases out of eight; 6) sclerotics not typically blue but in general the recognised features of osteogenesis

imperfecta present, with a history of multiple fractures, many healing without any tendency to hyperplastic callus.

CONCLUSIONS

In osteogenesis imperfecta the formation of callus is usually plentiful and sometimes rather excessive but the excess is absorbed in the normal way as consolidation occurs. In hyperplastic callus formation the amount of callus formed is large, or even enormous; and, once its limits are defined and ossification has occurred, some part of the original swelling remains as a thickening of the bone. "Callus" may form with or without injury and with or without fracture. The interest of the present case lies partly in the fact that there is no history of multiple fractures to indicate classical osteogenesis imperfecta, and partly in the familial incidence which has also been noted in other records. It is important to recognise the true nature of the condition in order to avoid the tragedy of unnecessary amputation. In one of Brailsford's cases the lesion is said to have become malignant but there is no other evidence in the literature that the condition has any relationship to malignancy. The clinical appearance can easily give rise to the suspicion of malignancy, and on histological examination the highly cellular and rapidly growing callus can be confused with a malignant condition. In fact, for the short time in which the bone formation runs riot the behaviour of a malignant neoplasm is closely simulated.

It is thought that the present account may be of interest because of the invariable relief of pain after x-ray treatment of each new lesion, the length of time over which the case has been followed and the resemblance between the radiographic appearances in the patient now and those of her aunt taken twenty years ago.

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HYPERPLASTIC CALLUS FORMATION IN OSTEOGENESIS IMPERFECTA

Report of a Case and Review of the Literature

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Hyperplastic callus in osteogenesis imperfecta is rare. I have been able to find only fifteen reported cases. The condition manifests itself by the formation of enormous masses of callus which may follow a fracture or a simple contusion or which may arise spontaneously without any preceding injury. Baker (1946) gave a classical account of the pathology and Fairbank (1948) gave an equally comprehensive picture of the clinical features. The first case report is by Battle and Shattock (1908) who described "a remarkable case of diffuse cancellous osteoma," the description and illustration of which leave no doubt that it was a case of hyperplastic callus formation.

Treatment is difficult and uncertain. One patient was subjected to amputation because the disease was mistaken for sarcoma. For the same reason another patient was treated by deep x-ray therapy but this was not effective. A further patient treated by deep x-ray responded favourably (Hilton 1934). In the case reported here, I had the opportunity of observing the early development of the condition in several bones at different times. I believed that any treatment could be effective only if given in the earliest stage of callus formation when its growth is most rapid and mitosis at its height.

CASE REPORT

An eleven-years-old girl had been under observation in the orthopaedic department of Alder Hey Children's Hospital under the care of Mr F. C. Dwyer, and had been treated altogether for six fractures. No member of her family had blue sclerotics or fragile bones. Her mother stated that she had no illness during pregnancy. Delivery was normal.

The patient sustained a mild head injury when seven months old and this was followed by a large swelling of the skull, but the radiographs did not show any bone injury. The swelling subsided after two weeks. She broke her right clavicle at the age of ten months, her right elbow at two and a half years and again at four, the left calcaneum at six years, the left clavicle at six and a half, and the left elbow at eight. The fractures of her elbows united with cubitus varus.

A radiograph of the spine showed mild flattening of the thoracic vertebral bodies such as is commonly seen in osteogenesis imperfecta. A radiograph of the pelvis showed small bony outgrowths of the iliac bones just above the acetabula.

When she was nine years old she noticed a lump in her right thigh. There was no history of injury. The radiograph showed a large bony excrescence of the upper part of the right femoral shaft (Fig. 1). A later radiograph of the forearms showed several small spiculed bony excrescences of the interosseous borders of the radius and ulna and a dislocation of the head of the left radius (Figs. 2 and 3). More recently the radiographs show hyperostotic ridges on the humeri and the upper end of the radius. These were first noted in the supracondylar region and subsequently they spread up the shaft, where their outline was wavy.

At the age of ten years she had a mild injury to her left thigh but was able to walk about for two weeks. After this she developed a limp and complained of pain in the thigh. Two weeks later marked tenderness of the lower third of the left femur was observed and

a vague thickening could be felt. She was admitted to hospital and her leg was immobilised by skin traction. *Investigations*—The blood sedimentation rate, blood count, serum calcium, inorganic phosphates, alkaline phosphatase and serum proteins were normal; the Mantoux test 1:10,000 was positive; the Wassermann reaction was negative. A radiograph at that time did not show any abnormality.

Progress—The next weeks were marked by a steadily increasing swelling of her left thigh. This was exquisitely tender and the superficial veins were enlarged. The temperature varied between 100 and 102 degrees, the sedimentation rate rose to 78 millimetres in the first hour and the white cell count to 11,000 cells per cubic millimetre. There was no material change in the blood chemistry apart from a rise of the alkaline phosphatase to 26·5 King Armstrong

FIG. 1 FIG. 2 FIG. 3

A curious excrescence of the right femur, noticed at the age of nine years (Fig. 1). Right elbow (Fig. 2) and left elbow (Fig. 3) at the age of nine years. Excrescences of the interosseous borders of the forearm bones. Dislocation of the head of the left radius.

units. Because of the pyrexia and extreme tenderness the diagnosis of osteomyelitis was considered, but when the swelling continued to increase sarcoma was suspected although hyperplastic callus formation was believed to be the most likely diagnosis.

A radiograph taken two months after the onset of pain showed periosteal elevation with marked new bone formation around the lower half of the femoral diaphysis (Fig. 5). There was no radiological evidence of bone destruction, but the dense new bone was deposited in the shape of "sun ray spicules."

Biopsy—On the same day Mr F. C. Dwyer removed a deep wedge for histological examination. The histological report confirmed the diagnosis of hyperplastic callus formation. *Macroscopically* the specimen consisted of a wedge of tissue 4·5 centimetres long, 2 centimetres deep and 1 centimetre wide at its superficial margin. The surface was slightly nodular and covered with a thin layer of fibrous tissue. Beneath this there was a firm gelatinous greyish-white zone grading more deeply into a whiter, more cartilaginous tissue. Both these zones varied in thickness from two to five millimetres. Superficially they were avascular; but more deeply,

FIG. 4

The swelling of the left thigh four weeks before it reached its peak

FIG. 5

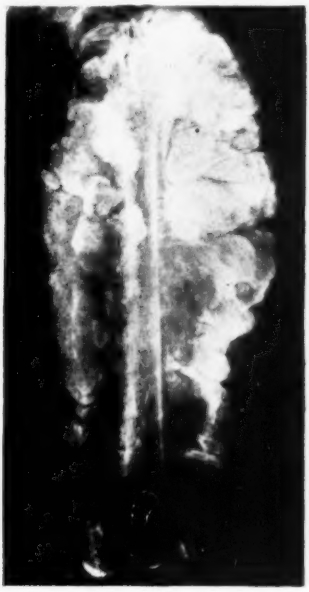

FIG. 6

Figure 5—Radiograph of the left femur five weeks after the onset of the hyperplastic callus formation. Figure 6—Hyperplastic callus formation at its height.

minute vessels could be seen running in a radial fashion. The inner part of the biopsy consisted of cancellous bone with a few small islands of cartilage. *Microscopically* the superficial part of the biopsy consisted of a zone of oedematous and fragmented connective tissue in which there were small haemorrhages and perivascular accumulations of lymphocytes and plasma cells. Deep to this there was a narrow zone of proliferation of fusiform and stellate fibroblasts, which changed gradually to a fibro-chondroid tissue arranged in irregular trabeculae separated by a loose vascular fibrous stroma. The deeper part of this zone showed calcification and true cartilage formation in the chondroid tissue with osteoclastic resorption at the margin of the trabeculae. Woven bone was being formed, and the deepest part of the biopsy consisted of trabeculae of woven bone and calcified cartilage with occasional central islands of uncalcified cartilage.

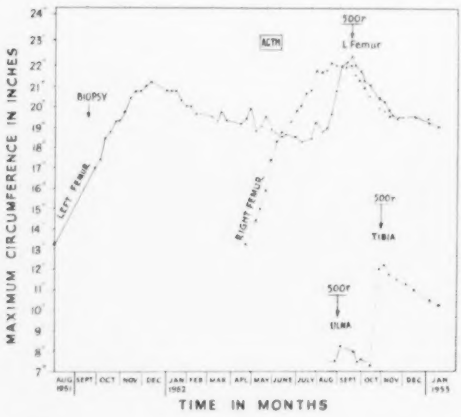

FIG. 7

Graph recording measurements of the greatest circumference of the limbs involved.

The appearances resembled those described by Baker (1946) in cases of hyperplasia of callus in fragilitas ossium. *Later progress*—The left thigh, from groin to below the knee, increased relentlessly, attaining a circumference of twenty-one inches six months after the onset as compared with the thirteen inches circumference of the right thigh at the same level (Figs. 4 and 6). During the next few months there was slight but steady shrinkage (Fig. 7). The temperature returned to normal and the blood sedimentation rate dropped to 13 millimetres in the first hour.

Five months later a swelling of the right thigh was observed; this had appeared without any injury while she was confined to bed in hospital. The radiograph and the rapid increase of the right thigh made it clear that this was also hyperplastic callus formation. She was given A.C.T.H. in the hope that this drug might cause cessation of the callus formation like its reported inhibition of granulation tissue (Howes *et al.* 1950). The swelling was unaffected (Fig. 7). In three months the girth of the right thigh reached its peak of twenty-two inches and thereafter diminished gradually. After the A.C.T.H. therapy there was considerable generalised osteoporosis and marked biconcavity of the vertebral bodies. The hyperplastic callus of both femora took part in the generalised osteoporosis and there was slipping of the right upper femoral epiphysis.

A month later a new focus of callus appeared spontaneously at the upper end of the left ulna (Fig. 8). At the suggestion of Dr S. E. Keidan and with the kind collaboration of Dr P. Haslam a single dose of deep x-ray therapy (K.V. 240, H.V.L. 3·0 millimetres Cu) was given to the affected area a few days later. This was given through two parallel and opposed fields giving a tumour dose of 500 r. After this the callus did not increase further and the circumference of the forearm became normal within five weeks. A radiograph taken four months later showed only a trace of the callus.

Soon after the swelling of the left ulna appeared it was also noticed that the left thigh, which had been slowly diminishing, was again rapidly swelling. With the encouragement of the favourable response of the ulna to x-ray therapy, a single dose of 500 r was given to the left thigh which also soon began to diminish.

Soon afterwards a spontaneous swelling of the left tibia occurred. A radiograph showed hyperplastic callus at the mid-tibia and an apparently unconnected spontaneous

fracture of the upper end of the tibia without any callus formation (Fig. 9). The tibia was similarly irradiated and again there followed steady diminution of the swelling.

Comments—The notable features of this case are: 1) Mild fragilitas ossium of the post-natal, non-familial type with absence of blue sclerotics. 2) Enormous hyperplastic callus formation of the left femur after a mild injury without a demonstrable fracture, and similar callus formations of the right femur, left ulna and right tibia without any injury; these developed while the patient was in hospital and on an adequate vitamin C intake. This fact is of interest in view of the suggestion made by Brailsford (1943) that scurvy plays a part in the causation of this condition. 3) A.C.T.H. had no effect on the callus formation of the right femur, but a single dose of deep x-ray apparently arrested callus formation on the three occasions when it was tried. 4) Bony excrescences of the right femur, the interosseous borders of the forearm

FIG. 8

Early stage of hyperplastic callus at the upper end of the left ulna. This was aborted by deep x-ray treatment. Note also excrescences and compare with Figure 3. A hyperostotic ridge can be seen on the outer side of the lower end of the humerus.

FIG. 9

Left tibia: hyperplastic callus at the mid-tibia. Note greenstick fracture at the upper end of the tibia unconnected with the callus.

bones and the ilia, not associated with injuries; I believe that the dislocation of the head of the radius is due to the excrescences which meet in the interosseous space and thus push the radius outwards and forwards. 5) Hyperostotic ridges most marked in the supracondylar region of the humeri; these have formed only recently and are perhaps a special form of bony excrescences. 6) Prolonged pyrexia while the hyperplastic callus was forming. 7) Normal blood chemistry, with the exception of the high serum alkaline phosphatase.

REVIEW OF THE LITERATURE

Altogether fifteen cases have been reported of hyperplastic callus formation in one or several bones. Some of the cases have been described by several authors at different times. All except three occurred in childhood. Nine patients were male, six female. In seven patients only one bone was involved, in three patients two bones were involved, in two

patients three bones were involved, in one patient four bones were involved and in two patients five bones were involved. Of the thirty-three affected bones twenty-two were femora, six were humeri, three were tibiae, one was the ulna and one was the radius. There was a preceding fracture in twelve instances, there was no preceding fracture in thirteen instances, there were doubtful fractures in three instances, there was no mention of a fracture in five instances.

Hyperplastic callus formation has usually attained its peak after two to six months. Thereafter the affected limb diminished, but usually some permanent enlargement remained. No patient is reported to have died except one (Brailsford 1943) whose tibia became the seat of a sarcoma. Pyrexia was marked in two cases. Bony excrescences were present in eight of the fifteen cases. There was dislocation of the head of the radius in three cases, separation of the upper femoral epiphysis in two cases. Hyperostotic ridges were present in five patients and were a prominent feature in Hilton's case. Only two patients are reported to have had blue sclerotics and only one had a family history of osteogenesis imperfecta. The brother of the patient reported by Battle and Shattock suffered from the same condition, but no mention was made of underlying fragilitas ossium in either. In Hilton's case there was no osteogenesis imperfecta but the familial incidence was striking.

SUMMARY

A case of hyperplastic callus formation is reported in a girl of eleven; several bones were affected. There were no associated fractures. She is believed to be suffering from a mild non-familial type of osteogenesis imperfecta without blue sclerotics and presents multiple bony excrescences unassociated with injury. The relevant literature is reviewed. The effect of a trial of treatment with A.C.T.H. and with deep x-ray is reported.

I wish to thank Mr F. C. Dwyer for his kind permission to publish the case of this patient who is under his care, Dr E. G. Hall for his pathological report and Dr S. E. Keidan for his help in the medical treatment. I am also indebted to Dr J. S. Fulton and Dr P. Haslam of the Liverpool Radium Institute for carrying out the radiotherapy and to Mr T. Gordon and Mr R. R. Green for the photographs.

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CALCINOSIS

Report of Two Cases

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In broad terms, the classification of calcification of soft parts is divided into four groups: metastatic, dystrophic, myositis ossificans and calcinosis; but, as the pathogenesis of many of the "calcifications" is unknown, such a classification must be an arbitrary one, and not always satisfactory.

Thus in the group of metastatic calcifications there are some that are associated with a wide variety of other conditions such as nephritis, multiple myelomatosis, myeloid leukaemia, sarcoma, hyperparathyroidism, Albers-Schönberg disease, and even osteomyelitis and caries of the spine. Changes in calcium metabolism are demonstrable in only a few of these conditions—notably in hyperparathyroidism.

In the dystrophic calcification group are included, for example, hydatid cysts and valvular and tendon calcifications. A separate group is formed for the myositis ossificans of traumatic origin, and with these should be included the paracondyloid ossification of the Pellegrini-Stieda type, ossifications of the coraco-clavicular ligaments and other calcareous deposits of clearly traumatic origin.

Calcinosis, on the other hand, is an anatomical, pathological, radiological and clinical entity showing pathological calcification in which multiple deposits of calcium are laid down in the skin, in the subcutaneous tissues and in connecting structures of deeper tissues; so far no case has been described in which calcification in internal organs or viscera has been demonstrated, either on radiographic examination or at necropsy.

The first case of calcinosis was described by Teissier in 1877. Steinitz (1931) reviewed the literature of calcinosis and divided it into two groups: "calcinosis circumscripta" and "calcinosis universalis." As the pathogenesis of the affection is still obscure, however, the division of calcinosis into two groups is a somewhat forced one, seeing that not even the topographic distribution of lesions allows a sufficiently distinct dividing line to be drawn always between the two alleged forms. Despite this limitation we must mention that "calcinosis circumscripta"—also described as calcareous granuloma, subcutaneous calculus, subcutaneous lithopexia, and calcareous gout—occurs mostly in adults and more frequently in women (in a ratio of six to one), the calcareous deposits appearing in the upper limbs, especially in the fingers. In "calcinosis universalis" the calcareous deposits occur not only in the superficial but also in the deeper tissues and show a tendency to spread, which is slow and intermittent. It is somewhat more frequent in the very young. The "universal" type is less common than the "circumscribed."

In the published discussions on the etiology of this curious pathological process, some of the opinions expressed appear to have been dictated by the preferences of their authors or have been due to more or less circumstantial evidence. Generally speaking, those inclined to the "inner" view look upon the disease *ab initio* and consider that the observed deposition of calcareous salts represents more than a form of fixation of the calcium in tissues previously altered by causes still unknown. Other authors seek a direct cause-effect relation, linking the calcareous deposits with biochemical and endocrine disturbances not yet understood or demonstrable. Others continue to inquire into the possibilities of a common etiology with apparently allied affections such as sclerodermia and sclerodactyly (Thibierge-Weissenbach

syndrome), Raynaud's disease, acrocyanosis, fibrous myositis, hyperparathyroidism and hypervitaminosis D; the latter two parallelisms have been derived from animal tests.

The diagnosis of calcinosis rests upon the demonstration of the calcium deposits of characteristic type and distribution. It has to be distinguished from calcified lipomas,

FIG. 1

Case 1—Initial radiograph at age two showing congenital dislocation of the right hip but no calcareous deposits.

FIG. 2

FIG. 3

Case 1. Figure 2—Fifteen months later. Age three and a quarter. Figure 3—Twenty-one months later still. Age five.

phleboliths, calcified ganglia, metastatic calcifications, gout, myositis ossificans and dystrophic calcifications.

Calcinosis is compatible with reasonable longevity, though function of the locomotor system is often seriously impaired and cosmetic blemishes may be severe. Spontaneous cure has sometimes been observed. No effective treatment is known.

CASE REPORTS

Case 1. *Calcinosis universalis with congenital dislocation of the hip*—Girl aged three years at first attendance. At the age of two years a limp had been noticed and radiographs showed a congenital dislocation of the right hip (Fig. 1). There were no signs of abnormal deposits in the soft tissues of the thighs. For reasons not known she received no treatment for the hip. In July 1950 she was referred to this hospital where further radiographs confirmed the existence of a congenital dislocation of the hip, but also revealed the existence of calcinosis (Fig. 2). There were numerous areas of calcification, some rounded, others in thick bars, grouped around the iliac bones and the proximal epiphyses of the femora. In the right thigh there was a thick bar due to the confluence of small oval elements of high density. Further medially there was another similar bar, extending obliquely to the junction of the middle and lowest thirds of the thigh in the line of the muscle planes. In the left thigh areas of calcification were apparent on the medial aspect only. Radiographic examination of the rest of the body did not reveal other deposits. Blood examination showed no significant abnormality.

FIG. 4
Case 2—Radiograph showing calcareous deposits in both thighs, discovered accidentally.

Progress—Attempted manipulative reduction of the dislocation was unsuccessful and operation was advised. The parents were slow in accepting this advice so that the operation was not performed until the child was four years old. Nine months after the operation radiographs showed that not only had reduction been maintained but also that the calcinosis appeared to be completely arrested. Further examination another year later showed no extension of the lesions (Fig. 3).

Comment—The curious aspect of this case is the demonstration of a pathological process which produced extensive calcareous deposits in less than a year and yet became stabilised, with no further extension of the lesions, within fourteen months of the first radiological confirmation.

Case 2. *Calcinosis universalis*—Man aged forty-six years. Radiographic examination undertaken on account of pain in the spine and hips revealed evidence of calcinosis in both thighs (Fig. 4). Radiographs of the rest of the body were normal. Examination of the blood showed normal findings.

Comment—The calcinosis in this case was discovered incidentally in the course of routine examination for back pain.

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A CASE OF INFANTILE CORTICAL HYPEROSTOSIS AFFECTING ONLY THE CLAVICLE AND SCAPULA

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Infantile cortical hyperostosis was the name suggested by Caffey and Silverman (1945) when they published the cases of four children with deposition of subperiosteal new bone on the long bones and mandible, though, as Fairbank (1951) pointed out, Roske published the first case in 1930. Reported cases are summarised in Table I.

CASE REPORT

Boy aged two months at onset. Normal birth after normal pregnancy. Bottle-fed because the mother suffered from tuberculosis. The mother noticed a tender swelling over the child's right clavicle and that he was averse to using the right arm. Admitted with temperature of 100 degrees, pulse 120; acute osteomyelitis was suspected.

Examination—The skin overlying the clavicle was pink and slightly warm. There was diffuse tender thickening of the clavicle. No other bones were affected clinically or radiographically. Radiography showed a casing of new periosteal bone over the entire length of the right clavicle (Fig. 1). Pseudoparesis of the right arm was present.

Pathological investigations—Blood cultures were negative; blood sedimentation rate was 63 millimetres in one hour, and the Mantoux, Wasserman and Kahn tests were negative. Haemoglobin was 59 per cent (Haldane), red blood corpuscles were 3,750,000 and white blood corpuscles 11,600; differential count showed polymorphs 42 per cent, lymphocytes 48 per cent, eosinophils 2 per cent, mononuclears 8 per cent; the red corpuscles showed marked anisocytosis, moderate hypochromia and slight microcystosis.

FIG. 1

Age two months. New bone formation encasing right clavicle.

Progress—Intramuscular penicillin was given for three weeks. At that time there was no evidence of involvement of the right scapula. Two weeks later the child seemed to be gaining weight normally and had a normal appetite. The clavicle was not further altered (Figs. 2 and 3), but clinically a small nodule was palpable in the body of the right scapula. After a further two weeks the child was beginning to use the right arm. The clavicle felt smaller. The right scapula was much increased in size, and marked thickening of the bone was shown radiographically (Fig. 4).

Five months after the onset the right clavicle and scapula were virtually the same size as the left. The child was using the arm fully and was normal and healthy with weight increasing at normal rate. A month later there was clinically no distinction between right and left scapulae and clavicles, and no other abnormalities were detected. Radiographs showed almost complete subsidence of bony changes (Fig. 6).

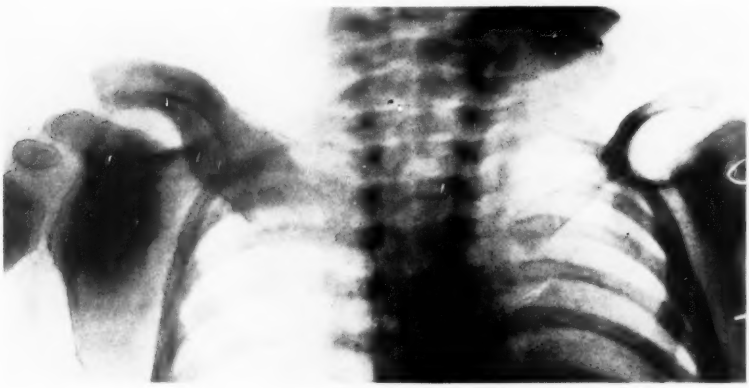

FIG. 2

Age two and a half months. Note marked thickening of right clavicle.

FIG. 3

FIG. 4

FIG. 5

Figure 3—Age three and a half months. No further new bone formation has occurred.
Figure 4—Right scapula at age four months. Figure 5—Left scapula for comparison.

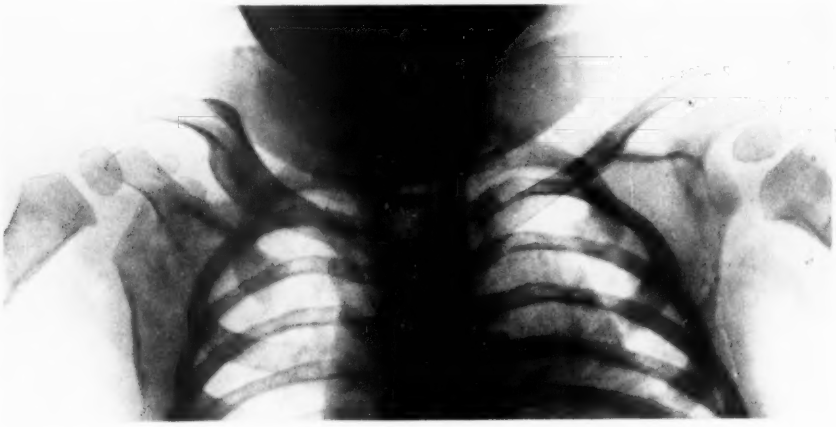

FIG. 6

Age six months. Resolution of the bony changes is almost complete.

COMMENT

When first seen, this child was thought to be suffering from typical osteomyelitis, but the temperature was never high and toxic symptoms were never great. The condition was not influenced markedly by penicillin; indeed, two weeks after cessation of the penicillin, a similar process began in the contiguous scapula.

During eighteen months the bony changes slowly declined and this case appears to satisfy the canons of the syndrome as regards local swelling, pain, pyrexia, leucocytosis, radiographic changes and the benign course. The absence of involvement of the mandible both clinically and radiographically is, however, atypical.

I am most grateful to Mr G. P. Arden for his kindly criticism.

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APPENDIX

Summary of Reported Cases of Infantile Cortical Hyperostosis

Author	Age at onset (*months*)	Presenting symptoms	Bones affected	Soft tissue swelling	Fever	Leucocytosis	Anaemia	Other features	Duration
Roske (1930)	1¾	Irritability, tenderness legs	Tibiae, humerus, radii, mandible	Lower legs, arm, jaw	—	+ (W.R. — ve)	—	Biopsy	Clinically and radiologically normal at 9 months except some tibial bowing
Ellis (1939)	4	Fretfulness, swelling left forearm, poor weight gain	Left radius, ulnae	Left forearm	—	—	—	Suggestion of vitamin C deficiency from urine tests	Subsiding after 2 months
Caffey and Silverman (1945)	1¾	Fever, irritability, tenderness left leg	Mandible, clavicles, ribs, right humerus, femora, tibiae	Both legs	+	+	+ *	Pleural exudate, spleen palpable	Inactive at 4 months, normal at 6 years
	2	Swelling face, fever	Mandible, ribs, humeri, radii, ulnae, femora, tibia	Face, forearms	—	—	+	Pleural exudate	Radiological changes after 10 months, normal at 5 years
	2½	Swelling face, irritability	Mandible, clavicles, left scapula, ribs, left humerus, femora, tibiae	Face, scapular region	+	+	+	Pleural thickening, seborrhoeic dermatitis	Practically normal in 10 months
	½	Swelling scapular region, restricted shoulder movement	Mandible, clavicle, right scapula, humeri, femora	Face, scapular region	—	—	—	Elevation right diaphragm, dysphagia	Radiological changes remain at 4 years
Caffey (1946)	4	Swelling cheeks, irritability	Mandible, clavicles, right radius, ulnae	Face, neck	+	+	+		Asymptomatic after 3 weeks
	18	Swelling left leg and foot, irritability, anorexia	Clavicles, ribs, right ulna, right femur, left tibia, right fibula, metatarsals	Left leg and foot	—	—	— *	Night sweating	Asymptomatic after 9 months but radiological changes remain
	1¾	Swelling cheek	Mandible	Face	—	+	—		Asymptomatic after 9 months but radiological changes remain
	4	Swelling face, fever	Radius, femora, tibiae, tibulae (other bones not radiographed)	Face, right leg	+				Still febrile after 4 months. No further F.U.
	20	Fever, aching joints, refusal to walk	Left clavicle, left radius, ulnae, right femur, tibiae, metatarsals		—		—	Tenderness long bones	Asymptomatic after 2 weeks
	3	Swelling face	Parietal bones, mandible, right clavicle	Face, scalp, sterno-clavicular region	—	+	+		Still symptoms after 8 weeks

* E.S.R. raised

APPENDIX—*continued*

SUMMARY OF REPORTED CASES OF INFANTILE CORTICAL HYPEROSTOSIS

Author	Age at onset (*months*)	Presenting symptoms	Bones affected	Soft tissue swelling	Fever	Leucocytosis	Anaemia	Other features	Duration
Smyth *et al.* (1946)	3½	Irritability, tenderness face	Mandible, ribs	Face	+	+	✻		
	3	Fever, irritability, swelling face	Mandible, clavicles, ulnae, femora, tibiae	Face, forearms, legs	+	—	— ✻	Shadow superior mediastinum	Normal after 2 years
	4½	Irritability, swelling face, gastroenteritis	Mandibles, clavicles, left humerus, radii, ulnae, femora	Face, arms, left leg	+	+	✻		Slight residual changes after 6 months
	2	Upper respiratory infection with fever and irritability	Mandible, ribs	Face, left scapular region	+	—	+ ✻		
	3	Swelling face and pain	Nil	Face	+	+	+	"Suggestion of pleurisy" in radiograph	
	21	Intermittent swelling arms, feet, scalp	Clavicle, ribs, ulna, right femur	Scalp, neck, left forearm, legs, feet		+	+		Much improved after 9 months
	30	Intermittent fever, irritability	Nasal bones, radius, ulna			—	—	Malnourished	
Dickson *et al.* (1947)	2	Swelling scapular area	Mandible, right clavicle, right scapula	Scapular region		+	+		Cleared in 7 months
Whipple (1947)	3	Irritability, tender swelling face	Skull, mandible, clavicles, ribs	Face, occiput	+	+	+		
Fisk (1947)	4	Swelling cheek and forearm	Mandible, right ulna	Face, neck, clavicular region	+	+	+		Almost cleared in 6 months
Burke and Ross (1948)	3½	Swelling face	Mandible, left clavicle, ribs, left ulna	Face, left arm	+	+	+ ✻	Primary T.B. lesion in chest, spleen palpable	Cleared in 6 months
Shuman (1948)	4	Swelling face, fever	Mandible, clavicles, ribs	Face, right forearm, clavicular region	+	+	+		Almost cleared in 6 months
Gipson and Clark (1948)	2	Swelling and tenderness right forearm	Mandible, clavicles, scapula, ribs, right radius, right ulna	Face, right forearm, clavicular region	+	+			Still present after 6 months
Van Zeben (1948)	1½	Swelling left leg	Clavicles, right humerus, left tibia	Left leg	—			Parents have had syphilis	Disorder disappeared after 13 months
	2	Swollen painful legs	Mandible, humeri, radii, tibiae	Mandible, legs	—	+	+ ✻	Brother of previous case	Died with mastoiditis 3 weeks after admission
	3	Swollen painful legs	Humerus, radius, ulna, femur, tibiae	Legs	—	+	—	Cousin of 2 previous cases	Improving radiologically 18 months later

✻ E.S.R. raised

APPENDIX—*continued*

SUMMARY OF REPORTED CASES OF INFANTILE CORTICAL HYPEROSTOSIS

Author	Age at onset (*months*)	Presenting symptoms	Bones affected	Soft tissue swelling	Fever	Leucocytosis	Anaemia	Other features	Duration
O'Reilly (1949)	2	Swelling face, fever, diarrhoea	Mandible, ribs, long bones, pelvis	Face, limbs	+	+	+	Generalised lymphadenitis	Residual broadening some bones at 15 months
Bradlow and Steinberg (1950)	3½	Tenderness jaws	Mandible (whole)	Face	100 (W.R. — ve)	16,000	7·8 gms.	Local adenitis. Added C.L.O.	Subsided 3 months. Clear 6 months
	2½	Tenderness jaws	Mandible (right ramus)	Face, right side	101 (W.R. — ve)	9,250	11·2 gms	Pyloric stenosis (1/12) operated upon. Added C.L.O.	Subsided 9 weeks. Clear 5 months
MacGregor and Davies (1949)	1½	Swelling left thigh	Left femur, slightly right femur, later left humerus, left ulna	Left thigh	Not stated at onset (W.R. — ve)			Added C.L.O.	8 months
Sakula (1950)	3½	Swelling, tender right forearm	Radius, ulna, mandible, clavicles, tibiae, pelvis	Forearm, jaw clavicles	-	-	-	Nil	6 months
Bush and Merrell (1952)	4	Fever, irritability, tenderness right cheek	Clavicle, mandible, ulna	Face, clavicular region	+	+	+	Corticotropin given	Cleared in 4 months
Hallock (1951)	3	Tender shoulder, lump axilla	Scapula, mandible	Scapula, jaws	99	-	-	Biopsy	Cleared in 7 months
	4½	Larger leg, irritability, pseudoparesis	Fibula, tibia, mandible	Lower leg, face	- (Kahn — ve)	-	-		Almost clear in 6 months
Rosenblum and Greenberg (1951)	3	Irritability, tenderness face, pseudoparesis right arm	Mandible, clavicle, scapula, rib	Face	- (W.R. — ve)	-	-	Biopsy	Cleared in 3 months
	3	Irritability, salivation, tenderness face	Mandible, scapula, clavicle, ribs	Face, scapula, clavicle, ribs	- (W.R. — ve)	+	+		Cleared in 16 months
Thoman and Murphy (1950)	3	Swelling arm and thigh	Femur, humerus, scapula	Arm and thigh	-	-	-	T.B. in family. Father treated for syphilis	Cleared in 11 months
Matheson and Markham (1952)	4	Fever, facial swelling, irritability	Mandible	Face	- (W.R. — ve)				Death. Marasmus
	4	Irritability, facial swelling	Mandible, tibiae, femur	Mandible only	(W.R. — ve)				Still not wholly resolved in 6 months
Mossberger (1950)	5½	Tenderness and swelling arms. Ecchymoses	Humeri	Both arms	-	+	-	Biopsy ante-mortem	Died 3 months
Smitham and Palmer (1950)	2	Swelling left leg	Scapula, clavicle, humeri, femora, tibiae	Lower leg	- (W.R. — ve)	+	+	No systemic disturbances	Slow resolution over 2 years

DISPLACEMENT OF THE UPPER FEMORAL EPIPHYSIS IN A MAN OF TWENTY-SIX YEARS SUFFERING FROM SIMMONDS'S DISEASE FOLLOWING A HEAD INJURY

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Cases of Simmonds's disease complicated by displacement of the upper femoral epiphysis do not appear to be uncommon. Lerman and Means (1945) described two cases of Simmonds's disease following head injury. In the case to be described, a head injury, Simmonds's disease and displacement of the upper femoral epiphysis occurred in sequence in the same patient.

CASE REPORT

The patient, whose general build and physical state are described later, complained of pain in the left hip and shortening of the left leg. Two months previously he had slipped and fallen on the left hip. *On examination*, there was 2 inches of shortening of the left leg. Flexion, extension and adduction of the leg were full; abduction was limited to 30 degrees and medial

FIG. 1

and lateral rotation were absent. Radiographs showed displacement of the upper femoral epiphysis (Fig. 1).

During my examination of the hip I had been under the impression that I was dealing with a boy of about twelve to fourteen years of age and had attached no undue significance to the diagnosis of slipped upper femoral epiphysis. It was with great surprise that I discovered

his age to be twenty-six years. I promptly extended my examination beyond the skeletal system. The patient was of slight build but not abnormally thin. He was five feet one inch in height; there was no disproportion between the arms, trunk and legs. The hair of the head was of normal texture but the skin of the face was sallow and the facial lines appeared deeper and more obvious than usual. The skin of the trunk was also sallow, dry and scaly. The voice was unbroken and the external genitalia were normally formed but of juvenile dimensions. Both testicles were in the scrotum but there was no evidence of either pubic or axillary hair. His appetite had always been poor but his weight had remained steady.

On further questioning it transpired that at the age of eleven years he had fallen from a table on to his head but had not lost consciousness. Three weeks after that injury he had begun to suffer increasingly severe headaches which were soon followed by attacks of vomiting. He had been admitted to a London children's hospital. Unfortunately the records of the hospital have since been destroyed but his mother was told that no fracture of the skull was discovered on radiographic examination, and that a day after admission a trephine hole was made in the left side of the skull. Later he had been discharged from hospital completely free from symptoms, in which state he has since remained.

There was no evidence of pituitary hypofunction in other members of the family. His own physical appearance and pre-puberty state do not seem to have caused him either embarrassment or concern. For the last eight years he had worked as a plumber's mate.

Investigations—His average daily pulse was 80 minute; his morning temperature 97 degrees Fahrenheit and his evening temperature 98 degrees Fahrenheit. The haemoglobin estimation was 106 per cent and the basal metabolic rate was −37 per cent. A glucose tolerance test showed a fasting blood sugar of 35 milligrams per cent rising to 50 milligrams per cent in one and a half hours. The serum sodium was 322 milligrams per cent and the serum cholesterol was 310 milligrams per cent. Ketosteroid estimation showed an excretion of only 0·5 milligram in twenty-four hours. Stereoscopic radiographs of the skull and pituitary fossa showed no abnormality and a radiograph of one elbow showed an "epiphysial age" of about sixteen years. All these findings indicate a considerable deficiency in the secretions of the anterior lobe of the pituitary gland as is usually found in cases of Simmonds's disease.

COMMENT

It seems probable that the lesion in this case was a subdural haematoma. Lerman and Means (1945) point out that head injuries sufficient to injure the pituitary are usually sufficient to kill the patient. Only one of the two cases reported by them (that of a man of forty-eight) occurred after a non-penetrating injury and in that case the ketosteroid excretion was reduced to 1·4 milligrams in twenty-four hours and the blood sugar curve rose from 55 milligrams per cent to 91 milligrams per cent.

I am most grateful to Mr T. E. Stoker, of the St Helier County Hospital, for permission to record this case; to Dr Miller for pathological investigations and to Dr Lavelle for the loan of radiographs.

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PRIMARY ASYMPTOMATIC CALCIFICATION OF ARTICULAR CARTILAGE

Report of a Case

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A surveyor, aged forty-five, complained of pain, tenderness, and swelling in his right knee, of two weeks duration. At first mild, the pain increased to moderate severity and was aggravated by movement. There was no history of injury, locking, or limitation of movement. He had had intermittent brief attacks of mild pain and swelling of both knees, left ankle, and right shoulder during the previous three years.

On examination the right knee was warmer than the left; there was periarticular swelling

Fig. 1

Fig. 2

Right knee. Figure 1—Calcification of a granular type is seen in both semilunar cartilages. Figure 2—Layers of calcium can be seen on the deep surface of the patella, and parallel to the articular condyle of the femur. The suprapatellar tendon is also calcified.

and an effusion of fluid in the joint. There was tenderness over the medial cartilage adjacent to the medial ligament. The range of movement was full. The other joints showed no abnormality and there were no signs of disease elsewhere. The erythrocyte sedimentation rate was 12 millimetres at one hour (Westergren).

Progress—The symptoms and signs subsided within four weeks without treatment other than rest in bed. Four months later he had further slight pain in the right knee for four days, but without swelling.

* Work undertaken on behalf of the Medical Research Council.

Radiographic examination. Knees—There were osteoarthritic changes in both knees, but the most striking changes were in the articular and semilunar cartilages. Throughout all four semilunar cartilages there was a flocculent granular calcification, densest towards the surface and more marked in the lateral cartilages (Figs. 1 and 2). In each lateral projection there was a layer of calcification about a millimetre thick lying parallel to the posterior surface of the femoral condyles and separated from the cortical bone by a translucent zone. This layer bore no relationship to the calcified cartilages. Similar layers were seen parallel to the articular surfaces of the patellae. Both suprapatellar ligaments were calcified and there was some calcification within the articular cartilage of the right superior tibio-fibular joint.

It was evident from its shape and position that the calcium deposit lay in the more superficial layers of the articular cartilage, with short frond-like extensions into the deeper layers. At no point did the calcification reach the bone cortex. The appearance was compatible with either calcification of the superficial layers of articular cartilage cells, or an incrustation of calcium-containing material upon a deeply and extensively fissured articular surface. *Shoulders*—In the left shoulder a calcified layer a millimetre thick overlay the greater part of the projection of the head of the humerus (Fig. 3). The glenoid cavity contained a similar opaque layer of even thickness, in spite of the heaping up of the cartilage at the edges of the joint. Both opaque layers were granular, irregular in density, approximately regular in depth and separated from the normal calcified tissue by a thin translucent zone. The general appearance was like that seen in the knees. The right shoulder showed similar but less marked changes. *Left carpus*—A small triangular opacity was found in the proximal part of the joint between the lunate and the triquetrum, apparently within the articular cartilage of the triquetrum. The other joints of the hand and wrist appeared normal. *Spine*—Opacities were seen in or immediately deep to the anterior longitudinal ligament at the C.6–7 and T.10–11 intervertebral spaces. The remaining joints and ligaments of the spine were normal. *Other cartilaginous tissues*—No abnormal calcification was demonstrated in other joints or cartilages. Most of the joints were re-examined five months later but there was no significant change in their appearances.

FIG. 3

Left shoulder. Calcified cartilage is seen overlying the head of the humerus and lining the glenoid cavity.

DISCUSSION

Calcification near the edge of the intervertebral discs and in the semilunar cartilages of the knees is seen not uncommonly after middle life and might well have been present in this patient independently of the other abnormal calcification. The unusual feature was the calcification of the hyaline articular cartilage. This may be a sign of a generalised disturbance of cartilage metabolism, but such an explanation is unlikely since fibro- and elastic-cartilage elsewhere were not affected. The symptoms were slight, and since there was no indication for opening a joint no histological examination of the tissue has been possible. From the

radiographs, however, it is evident that there was a deposit of calcium within the superficial layers of the hyaline articular cartilage over the posterior surfaces of the femoral condyles and patellae, over the heads of the humeri and the glenoid fossae, and over the proximal surface of the left triquetrum. At each site the appearance was the same—an irregular flocculent opacity, generally densest towards the surface, with a translucent layer beneath it.

Although the patient had had symptoms in both knees, in the left ankle, and in the right shoulder, there was also abnormal calcification in the left wrist and in the left shoulder, yet both these joints were symptomless. Indeed, the abnormal calcification in the left shoulder was denser and more extensive than in the right. It is possible, therefore, that the symptoms in the right shoulder and both knees could have been due to early osteoarthritic changes alone and not to the calcification in the articular cartilage.

There are several reports in the literature of similar findings. Israelski (1931) published a radiograph of calcification of the semilunar cartilages which also showed a narrow band of calcification lying parallel to the articular surface of the femur, presumed by Israelski to represent an incrustation of calcium on the surface of the articular cartilage. Werwath (1928) described an example of calcification in a semilunar cartilage, detected radiographically. The knee joint was opened; large areas of calcification were seen on the articular cartilage of the femur and tibia and on the medial cartilage, which was removed and sectioned. Small areas of calcification were found in the cartilage. Wolke (1935) examined the radiographs of 2,569 knee joints and found calcification of the cartilages in eight. In five of these patients he described unilateral or bilateral calcification in the articular cartilage of one or more of the following joints: knee, hip, acromio-clavicular, shoulder, elbow, radio-ulnar-carpal, pubic symphysis. He also described calcification in the intervertebral discs. In some instances there was no history of symptoms in the affected joint and, in all patients but one, the symptoms that were present were those of osteoarthritis. Harmon (1944) described two examples of calcification of the articular cartilage over the femoral condyles, and he stated that in one patient similar changes were evident in the wrist joints. The symptoms in one case suggested osteoarthritis; in the other, gout.

We have used the title "primary asymptomatic calcification of articular cartilage" because there is no history of injury to the affected joints and the etiology is obscure; because the condition may clearly be present for long periods before symptoms arise, if they ever do; and because the calcification is within the superficial layers of hyaline articular cartilage, is polyarticular in distribution, but, apart from the constant accompaniment of calcification in the semilunar cartilages, there is no evidence of abnormal calcification in fibro- or elastic-cartilage. Whether the calcium is deposited within or around the cartilage cells, or whether it occurs as an incrustation laid down from synovial fluid, can be decided only by histological examination.

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EXPERIMENTAL ARTERIAL SPASM IN THE LOWER EXTREMITIES PRODUCED BY TRACTION

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Arterial spasm in an extremity may be produced in many ways. That localised trauma is responsible for widespread spasm has been shown experimentally by Barnes and Trueta (1942) and demonstrated clinically by Cohen (1944). Spasm caused by stretching a vessel has been observed at operation many times, but no reference has been discovered to experimental stretch of the entire vascular tree of a limb having caused widespread spasm. The following experimental work was prompted by the occurrence of vascular spasm in the lower extremity after traction in the treatment of fractures of the femur in childhood (Thomson and Mahoney 1951).

METHOD

It was believed that a satisfactory method of demonstrating spasm would be the radiographic study of contrast media (20 cubic centimetres of 70 per cent diotrast) in the vascular tree of dogs before and after stretch. The left kidney was removed; a polythene tube was introduced into the renal artery and passed to but not into the aortic lumen. This

Fig. 1

Fig. 2

Figure 1—Arteriogram before fracture. Figure 2—Arteriogram twenty-four hours after $\frac{3}{4}$ inch lengthening.

tube enabled repeated simultaneous arteriographic examinations of both lower extremities to be made. Stretch of the arterial system was obtained by distracting the divided femur through approximately five-eighths of an inch and plating the fragments in the lengthened position. The results are shown in Table I, Figures 1 and 2. In a second series of experiments the bone fragments were allowed to shorten for twenty-four hours after fracture; the wound was then reopened and the fragments plated in normal position (Table II, Figures 3 and 4). In a control series the femur was fractured and immediately plated in normal position and alignment (Table III and Figures 5 and 6).

TABLE I

STRETCH OF VASCULAR TREE FROM RESTING STATE

Dog number	Degree of spasm	Clinical observations
1	**6½ hours after lengthening:** Marked bilateral spasm. Main arterial trunks reduced to less than half normal calibre. Spasm slightly greater at level of fracture, and on lengthened side **22½ hours after lengthening:** Spasm persisting almost unchanged	Lengthened limb definitely colder than other extremities 32 to 48 hours after plating
2	**24 hours after lengthening:** Marked diffuse bilateral spasm of collateral and main vessels. Main arteries reduced to half normal calibre. Spasm more marked on lengthened side at level of fracture **48 hours after lengthening:** Spasm unchanged. Bone plate bent to 100 degrees	**42 hours after lengthening:** Lengthened limb swollen, cold and pulseless **72 hours after lengthening:** Signs more marked, gross oedema and coldness of limb
3	**24 hours after lengthening:** Slight spasm of main arterial trunk on lengthened side **80 hours after lengthening:** Spasm increased on lengthened side, but lengthening not maintained because bone plate bent	**72 hours after lengthening:** Slight oedema of lengthened limb. This persisted for ten days after lengthening
4	**26¾ hours after lengthening:** Moderate spasm of collateral vessels and slight spasm of main arteries, more marked on lengthened side. Lengthening not maintained because bone plate bent soon after fracture	No definite clinical signs

TABLE II

RETURN OF VASCULAR TREE TO NORMAL LENGTH AFTER SHORTENING

(Allowed to shorten twenty-three hours)

Dog number	Degree of spasm	Clinical observations
5	**25 hours after return to normal length:** Marked diffuse bilateral spasm of main and collateral vessels, slightly greater on side operated upon. Main arteries reduced to less than half normal calibre	**25 hours after return to normal length:** Hind limbs definitely colder than forelimbs. Dog killed after arteriograms taken
6	**23½ hours after return to normal length:** Collateral vessels completely obliterated on both sides, with only a thread of opaque fluid appearing in both main arteries	**23½ hours after return to normal length:** Hind limbs colder than forelimbs. Dog killed
7	**22½ hours after return to normal length:** Only a thread of opaque fluid entered the main trunk of the sound limb. No other vessels were visualised due to marked spasm	**15 hours after return to normal length:** Both hind limbs markedly colder than forelimbs **22½ hours after return to normal length:** Hind limbs grossly cold, more marked on side operated upon. Killed
8	**23½ hours after return to normal length:** Marked bilateral spasm equal on both sides, and greater at level of fracture. Main vessels reduced to half normal calibre	**23½ hours after return to normal length:** Definite coldness of lower (hind) limbs. Killed

FIG. 3

FIG. 4

Figure 3—Arteriogram before fracture. Figure 4—Arteriogram fifteen hours after return to normal length.

TABLE III

CONTROLS

Dog number	Degree of spasm	Clinical observations
9	**19 hours after fracture and plating:** No evidence of spasm. Collateral vessels well filled. Main arteries of same normal calibre	No clinical changes
10	**20 hours after fracture and plating:** No evidence of spasm. Pre- and post-operative films identical	No clinical changes
11	**22 hours after fracture and plating:** No evidence of spasm. pre- and post-operative films identical	No clinical changes

FIG. 5

FIG. 6

Figure 5—Control experiment: arteriogram before fracture and plating. Figure 6—Arteriogram twenty hours after fracture and plating without allowing to shorten.

DISCUSSION

From these experiments it is clear that stretching of the vascular tree from its normal resting state in one lower limb produces a variable degree of spasm in both main and collateral arteries in both extremities. Although it is difficult to produce gangrene and its preceding degenerative states in dogs (Callow and Welch 1950) early signs of Volkmann's ischaemia

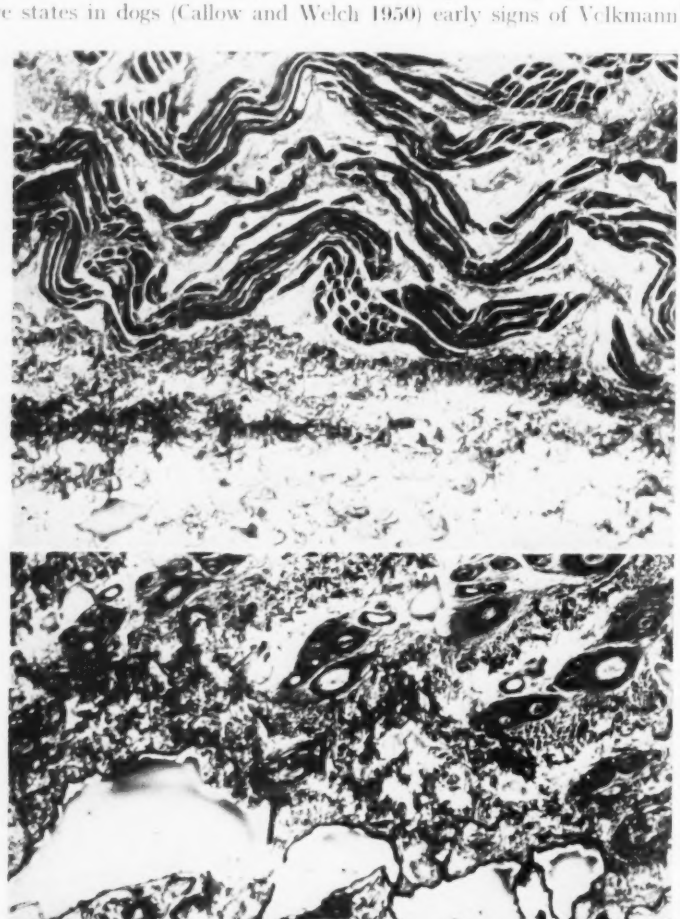

FIG. 7

Section through muscle, subcutaneous tissue and skin seventy-two hours after lengthening the leg; note the protein-rich oedema of muscle, subcutaneous tissue and skin (H. and E. × 48).

were associated with spasm of the vascular tree. Clinical evidence of ischaemia and radiographic evidence of spasm were both more marked on the lengthened side. The clinical changes found were coldness, lack of pulsation and oedema of muscle. On gross examination no obstruction was present in arteries or veins; the vessels themselves were pale and small. The muscle bellies exhibited a gross watery oedema; they were firm, swollen and pale.

Microscopic examination (Fig. 7) showed marked protein-rich oedema of muscle, subcutaneous tissue and skin. Dilated lymphatics were present in the connective tissue and rather marked vesiculation of the skin was noted. These gross and microscopic changes in muscle ischaemia have been described previously by Mustard (1946).

When a fractured femur is allowed to shorten for twenty-four hours and is then brought out to normal length the same findings of diffuse bilateral arterial spasm with clinical ischaemia are noted. Again spasm is more marked and the clinical findings are more pronounced on the fractured side.

CONCLUSIONS

1. Arterial spasm may be expected in any injury resulting in stretch of the arterial system.
2. Excessive traction in the treatment of fractures may well initiate diffuse arterial spasm.
3. In fractures that have permitted shortening of the vascular system for a considerable period, spasm may be initiated when a return to normal length is made.

This work, aided by a grant from the Banting Foundation, was done in the Department of Experimental Surgery, Banting Institute, University of Toronto. Dr H. J. Barrie and Dr C. R. Macrae, Department of Pathology, University of Toronto, interpreted the sections.

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THE NORMAL VASCULAR ANATOMY OF THE FEMORAL HEAD IN ADULT MAN

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This paper gives an account of an investigation into the normal vascular anatomy of the adult femoral head. The work was undertaken to supply control material for research into the vascular changes accompanying osteoarthritis of the hip joint, and for this reason no account is given here of the conditions existing in the two decades preceding maturity. These will be presented on another occasion. Similarly we have not detailed the extra-articular course and anatomical variations of the arteries supplying the femoral head; they have been fully described by others. We shall commence our description of the vessels from where they are about to enter the bone, precisely the point at which the available information grows increasingly scanty; here they begin their physiological role, their function as conducting channels now having been fulfilled.

HISTORICAL REVIEW

In the past this subject has been approached by two different types of investigators; one group, comprising mainly surgeons and anatomists, successfully identified the arteries bringing blood to the upper end of the femur but were less interested in determining the fate of these vessels within the bone. A second group, constituted by pathologists and haematologists, were concerned with the structure and arrangement of the finest vessels within the bone mainly in relationship to haemopoiesis.

Palletta (1820), Cooper (1823), Sappey (1869) and Langer (1876) were among the nineteenth century workers who studied the vessels bringing blood into the upper end of the femur; they were followed in more recent years by Lexer *et al.* (1904), Nussbaum (1924), Kolodny (1925), Logròscino (1934), Vereby (1942), Wolcott (1943), Tucker (1949) and Howe *et al.* (1950). Some of the most outstanding of the early contributions to the anatomical knowledge of the finer vessels within the bone were by Neumann (1869), Langer (1876), Rindfleisch (1880) and Van der Stricht (1892); later workers included Doan (1922 and 1925) and Drinker (1922) and their associates. In studies devoted to the larger vessels, once the main arterial pathways had been identified further reports tended to centre on discussion whether, during growth, the epiphysial plate constitutes an absolute barrier to the circulations of epiphysis and metaphysis and also what arterial contribution to the blood supply of the femoral head, if any, is brought by the artery of the ligamentum teres. Parallel discussions have concerned the anatomy of the small vessels, as to whether the capillary circulation of the marrow is partly an open, or is a closed system.

No elucidation of either of these artificially separated problems has been achieved by this dual approach, and consequently our knowledge of the complete circulatory anatomy within human bone in general and this region of constant orthopaedic interest in particular is seriously deficient.

DEFINITIONS AND NOMENCLATURE

Throughout this article the term epiphysis is applied to that part of the head of the femur formed from the secondary centre of ossification. During the growth period the extent of the epiphysis is made obvious by the growth plate which limits it infero-laterally (Fig. 1), and in adult life a distinction continues in that the so-called epiphysial scar serves as a guide

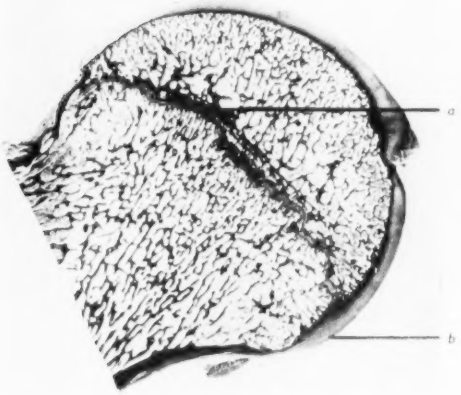

FIG. 1

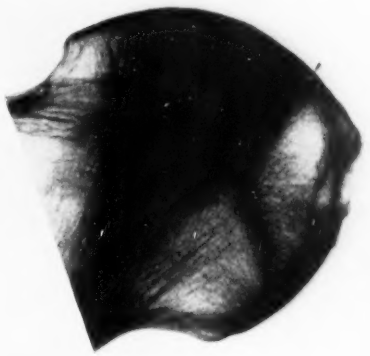

FIG. 2

Figure 1—Photomicrograph of a coronal section of a femoral head of a subject aged fourteen. *a*—Concentration of bone lamellae superficial to the epiphysial plate. *b*—Articular cartilage covering metaphysial bone (× 1·2). Figure 2—Slab radiograph, coronal plane, from the femoral head of a subject aged seventy-two. A radio-opaque zone, the "epiphysial scar," is seen to occupy a position close to that which the epiphysial plate did during the years of growth.

to the position which the growth plate previously occupied (Fig. 2). We have observed that the system of lamellar bone which constitutes the scar lies close to, but on the epiphysial side of the growth cartilage, and the scar does not represent a zone of intense ossification produced within the plate at the time of synostosis. It will be seen in Figures 1 and 2 that the upper femoral epiphysis does not form the whole of the femoral head either during or after the growth period; at both times the proximal part of the diaphysis, the metaphysis, forms a substantial part of the head and is covered by articular cartilage (*b*, Fig. 1).

MATERIALS AND METHODS

This study has been made exclusively on human specimens obtained after death. Due to certain factors as yet beyond control (agonal vasospasm, post-mortem intravascular clotting) there is a fortuitous element inherent in any attempt to fill the vascular tree, post-mortem, with contrast media and this has necessitated very many more injections than are reported here, the uninformative results being excluded from this paper. The material available for the analysis on which this report is based is shown in Table I.

TABLE I

AGE DISTRIBUTION OF THE INJECTED MATERIAL SUITABLE FOR ANALYSIS

(Thirty-six specimens)

Age of subject at time of death (*years*)	Number of femoral heads
20–30	2
31–40	2
41–50	1
51–60	1
61–70	12
71–80	11
81–90	5
91–100	2

The techniques used to visualise the blood vessels within the bone are based on those previously described in the investigation of another circulatory problem (Trueta *et al.* 1947). The arteries that supply the upper end of the femur have been injected with various materials: in most instances the injections have been given into the medial femoral circumflex artery, but the common iliac and common femoral arteries have also been used. When injecting a suitably excised specimen one can obstruct branches which might otherwise divert the injection mass away from the upper end of the femur. No attempt has been made to estimate the actual injection pressures used, because the pressure recorded in the syringe or nearby artery is no indication of the effective injection pressure in the vessels as they enter the bone.

The injection masses used in this study were barium sulphate suspensions (Ardran 1953), 10 per cent colloidal silver iodide, 2 per cent Berlin Blue, and Neoprene Latex solution. The barium suspensions and the colloidal silver, being radio-opaque, could be subjected to radiological analysis and, when necessary, microradiography; other injection media were studied by different techniques. Neoprene Latex casts of the vascular tree, obtained by digestion of the bone and marrow with acid after intra-arterial injection of Neoprene, can be dissected under water; Spalteholz's technique, by which the bone and marrow are rendered transparent, enables the vessels previously filled by one or more injections to be followed for long distances throughout their course by a binocular dissecting microscope. We have employed a number of different methods to reveal the vessels in order to minimise the errors of interpretation that can arise from the use of any one technique.

Radiographs were made in the antero-posterior and the medio-lateral positions of each specimen that had been injected with radio-opaque material. The specimen was then sawn up into slices approximately a quarter of an inch thick, the plane of section varying from specimen to specimen. These slices were radiographed at right angles to the plane of their section and were then decalcified; when this process was complete all the radiographic views described above were repeated, it being possible to reconstruct the specimen by fitting together the several slices. On many occasions stereoscopic radiographs were taken for any or all of the above projections. The microradiographic techniques used were those described by Barclay (1951).

The study of the smaller vessels has been mainly effected by microscopy of histological preparations obtained from injected material. Tissue embedded in 20 per cent low viscosity nitrocellulose was cut at thicknesses of either 15μ or approximately 400μ. Whereas the former were stained with Hansen's haematoxylin and eosin, the thicker sections were examined unstained by low power microscopy.*

RESULTS

We have found that the vascular patterns established during the phase of growth are not replaced at maturity but largely persist throughout life, and thus one can speak of epiphysial and metaphysial circulations even in advanced years; we shall show below that when the two territories become one by the disappearance of their cartilaginous frontier their circulations still retain some autonomy. The epiphysis and the metaphysis usually receive blood from separate sources and we shall call the vessels epiphysial and metaphysial in accordance with their destinations. By reference to their sites of entry into the bone (Fig. 3) the epiphysial arteries are named lateral and medial, and the main metaphysial arteries superior and inferior. The lateral epiphysial and both groups of metaphysial arteries usually arise from the medial femoral circumflex artery; the medial epiphysial artery is a continuation of the artery within the ligamentum teres which comes from the acetabular branch of the obturator artery.

A detailed assessment was made of the relative contribution that these sets of vessels made within each territory, and for this analysis fifteen injections were selected whose quality was such as to allow the finer branches of each artery to be followed to their limits. It was found that the lateral epiphysial arteries predominate in the epiphysis and the inferior metaphysial arteries in the metaphysis. The lateral epiphysial arteries supplied at least four-fifths of the epiphysis in seven cases, in a further seven they supplied two-thirds of the zone and in one case slightly more than half. The inferior metaphysial arteries were found

* If a block is sectioned serially, cutting alternately at 15μ and 400μ, it is possible not only to follow any vessel throughout the block by studying the thick unstained sections, but accurate superimposition of a stained thin section over its preceding or following thick section will allow identification of any particular vessel.

to supply about two-thirds of the metaphysial tissue that is within the femoral head. These proportions represent only the more usual arrangement and must be subject to considerable variation; for example, the contribution coming from the artery of the ligamentum teres may be negligible or absent in some cases.

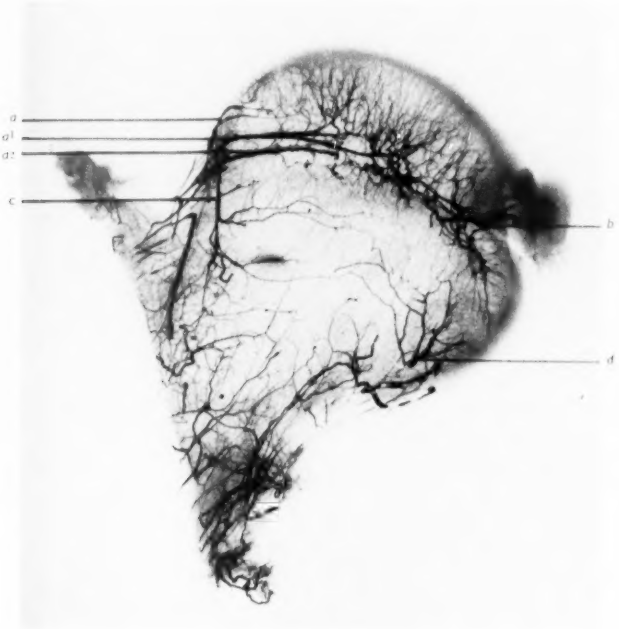

FIG. 3

Angiogram of a thick coronal slice of a femoral head of a subject aged twenty. Injection mass, barium.

a, a^1, a^2—Lateral epiphysial arteries. *b*—Medial epiphysial artery. *c*—Superior metaphysial artery. *d*—Inferior metaphysial artery.

The epiphysial arterial pattern. *The lateral epiphysial arteries* (Figs 3, 6, 7, 12 and 23) enter the head superiorly and postero-superiorly, usually two to six in number and often spiral in form for a short distance after their entry (Fig. 4); in this position they always lie within a thick fibrous sheath (Fig. 5). In their course they follow closely the line of the old epiphysial plate, but lie some distance above it superficial to the epiphysial scar. They run downwards and medially, and, as can be seen in lateral radiographs, somewhat anteriorly as well, in a gentle curve directed towards a point on the articular surface between the fovea capitis and the inferior articular margin. The constituent arteries of the group vary in size: one is usually larger than the others and there is frequently one vessel whose branches are distributed exclusively to the supero-lateral segment of the epiphysis. *The medial epiphysial artery* (Figs. 3 and 23) and its main branches run laterally on the same level as the fovea capitis through which they have entered, until they meet and anastomose with the main lateral epiphysial vessels; the length of their course is proportional to their size. This anastomosis was frequently demonstrated by the outflow of the injection medium from the artery of the ligamentum teres on injection of the medial femoral circumflex artery.

The predominant direction of distribution of the branches from these main epiphysial arteries is into the epiphysis and towards the joint surface; in comparison the outflow to the metaphysis is small. The epiphysial vessels are arranged in a characteristic series of arterial

FIG. 4

Radiomicrograph showing a lateral epiphysial artery bifurcating immediately before entering the femoral head. Its branches describe a spiral in the first part of their intracapital course. Injection mass, barium (× 16).

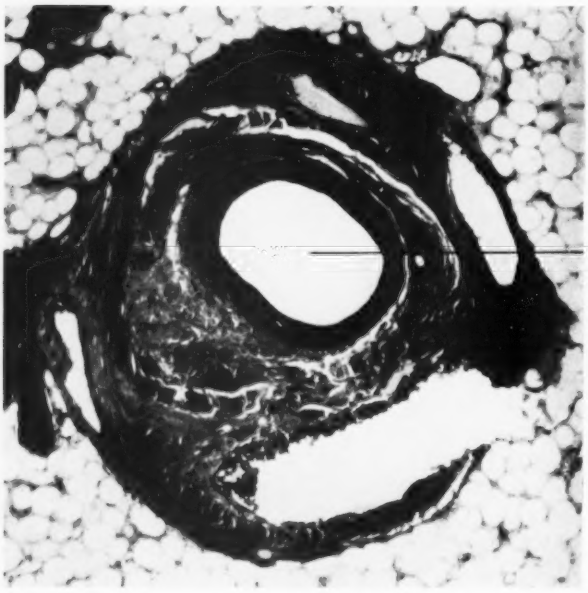

FIG. 5

Photomicrograph of a lateral epiphysial artery (*a*) cut in the sagittal plane. The vessel was approximately at the position shown in Figure 4 and lies in the centre of a fibrous sheath which also contains four veins (× 52).

arcades constituted in the following manner. The branches leaving the parent stem or its main divisions do so at an angle of approximately 90 degrees and follow a course directed perpendicularly to the joint surface; this radial arrangement obtains irrespective of whether the vessels are studied in coronal (Fig. 6), sagittal (Fig. 7) or horizontal sections. Neighbouring vessels running roughly parallel in this fashion form the sides of arches which are completed by a communicating branch usually of the same calibre as that of the two vessels it is uniting (Figs. 8 to 10). The summits of the arches, like their supporting pillars, are directed towards the surface and from these arches further branches are given off which themselves are subject to the same arrangement. Two or three tiers of such arches are found in the epiphysis lying

FIG. 6

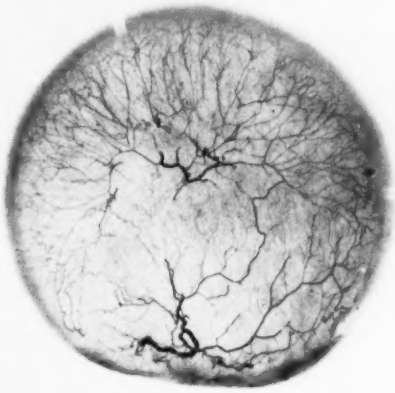

FIG. 7

Preparations to show the arterial pattern within coronal (Fig. 6) and sagittal (Fig. 7) slices of the femoral head. Figure 6—Photograph of a Spalteholz preparation subject aged seventy-five. Injection mass, barium. A considerable part of the course of the lateral epiphysial artery is seen. This vessel separates the tiers of arterial arches in the epiphysis above from the vessels of the metaphysis below. Figure 7—Angiogram, subject aged seventy-six. Injection mass, barium. The epiphysial artery lies just above the centre of the specimen and its branches are distributed to the epiphysis, which in this section has the form of an inverted crescent. The large vessel lying inferiorly is the main inferior metaphysial artery and its branches anastomose with the epiphysial system.

between the main vessels and the articular cartilage. Stereoscopic studies reveal that any one of the radially running branches can contribute to several arches lying in different planes; it is as though a series of fountains were arranged in such a fashion that the spray from any one fell into the rising columns of its neighbours on all sides. This characteristic pattern of the smaller intra-osseous arteries is a feature of the epiphysis and not merely of the branches of the lateral epiphysial artery; the branches arising from the medial epiphysial artery behave in exactly the same manner.

The metaphysial arterial pattern (Figs. 3, 6, 7, 12 and 23).—There are usually two, three or four *superior metaphysial arteries* arising from the vessels which will soon give origin to

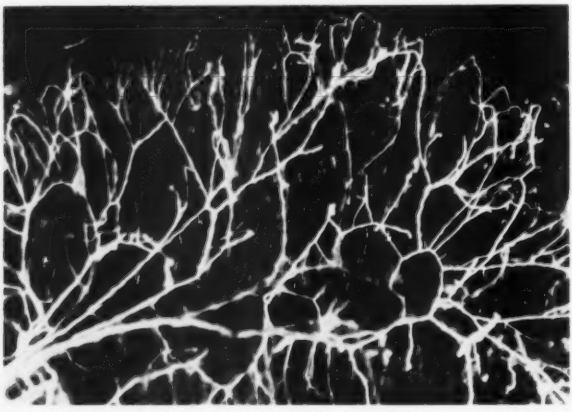

FIG. 8

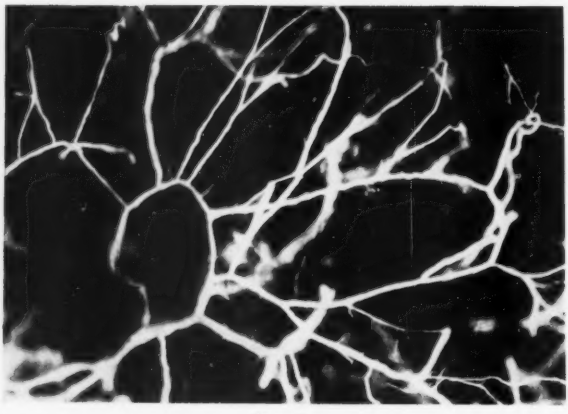

FIG. 9

FIG. 10

Photomicrographs of the epiphysial arteries within the femoral head of a subject aged seventy-five. In Figure 8 are shown the tiers of arches running from the main lateral epiphysial vessel below to the articular surface above (×2·6). Figures 9 and 10 show details of arch systems (×6). Injection mass, barium. Spalteholz preparation.

the lateral epiphysial group. These metaphysial vessels enter the superior aspect of the femoral neck some distance from the margin of the articular cartilage and have an absolutely straight course vertically downwards into the bone; when they have passed about a quarter of the way across the femoral neck they suddenly turn supero-medially in a smooth curve towards the site previously occupied by the epiphysial plate. The *inferior metaphysial arteries* enter the bone close to the inferior margin of the articular cartilage. There is frequently one vessel larger than any other of the group and it describes a short spiral before breaking up into branches which run up towards the epiphysis. The smaller arterial branches from these sets of metaphysial vessels are distributed throughout the metaphysis; the arching system of anastomoses seen in the epiphysis is absent here and the pattern is more one of branching vessels of decreasing calibre pursuing straight or angular courses towards the epiphysis.

The terms superior and inferior metaphysial arteries apply to groups of vessels which are in some respects less well defined than the lateral and medial epiphysial arteries. Before they enter the bone, the metaphysial arteries, by their frequent interconnecting anastomoses

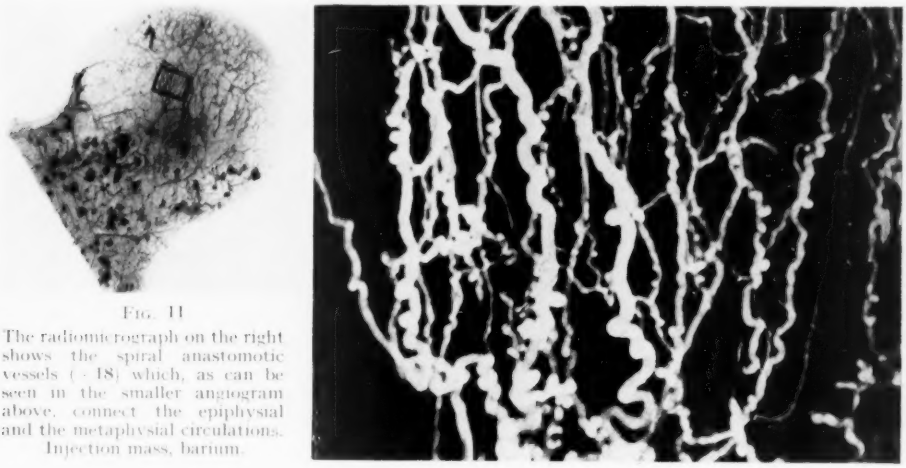

FIG. 11

The radiomicrograph on the right shows the spiral anastomotic vessels (× 18) which, as can be seen in the smaller angiogram above, connect the epiphysial and the metaphysial circulations. Injection mass, barium.

in the sub-synovial tissues, conform to the pattern so clearly described by Hunter (1743) and named by him the circulus articuli vasculosus. On the neck of the femur the circle tends to be deficient anteriorly, and "the vascular border of the joint" is most evident superiorly and inferiorly; it is here that the main arteries running to the metaphysis are found. Quite frequently the circle has some representation posteriorly in virtue of small arteries on the back of the femoral neck running in part into the metaphysis but we have not described these as a separate metaphysial group, rather preferring to emphasise the major sources.

Anastomoses.—There is a free anastomosis inside both the epiphysis and the metaphysis between the vessels which supply each territory; in addition there is anastomosis between the vessels of the two territories at the site previously occupied by the growth plate. A series of connecting branches leave the main epiphysial arteries at right angles and run downwards into the metaphysis; in calibre they are usually smaller than the vessels of the epiphysial arches and in form they are frequently spiral (Fig. 11). Just as the metaphysis is a somewhat arbitrary subdivision of the diaphysis so the free anastomosis there of the metaphysial arteries and those within the neck of the femur prevents any attempt to define the lateral limits of the metaphysial circulation. It may be noted here that we have not seen any evidence of the nutrient artery of the femur extending its area of supply up to the metaphysial region as has been so frequently stated.

Changes in the vascular tree with age—In this study we have examined specimens from persons who ranged in age from twenty to one hundred years and we have been impressed with the complete absence of any decrease in patency of the vascular tree with advancing years (Fig. 12). The failure to visualise a particular vessel or vessels by any of the techniques we have used gives no proof of their absence. In our experience a complete filling of even the arterial tree has never been achieved; tissue which had yielded our best angiograms, on subsequent histological section showed areas in which the vessels, though present, had not been filled. Whether this failure is due to the crudity of our present methods or whether it implies an intermittency of the circulation such as some authors describe in other organs (Richards and Schmidt 1924, Krogh 1929) cannot be decided; it has certainly been observed that the vessels of resting zones in other tissues have been extremely difficult to fill by injection.

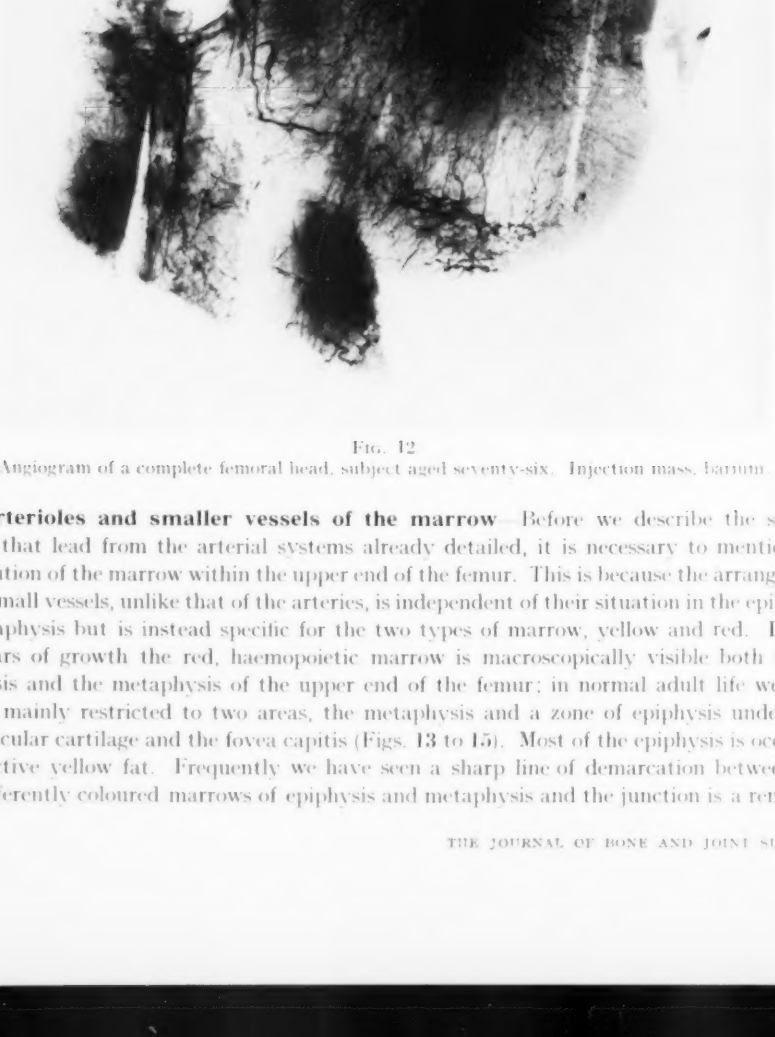

FIG. 12
Angiogram of a complete femoral head, subject aged seventy-six. Injection mass, barium.

The arterioles and smaller vessels of the marrow—Before we describe the smaller vessels that lead from the arterial systems already detailed, it is necessary to mention the distribution of the marrow within the upper end of the femur. This is because the arrangement of the small vessels, unlike that of the arteries, is independent of their situation in the epiphysis or metaphysis but is instead specific for the two types of marrow, yellow and red. During the years of growth the red, haemopoietic marrow is macroscopically visible both in the epiphysis and the metaphysis of the upper end of the femur; in normal adult life we have seen it mainly restricted to two areas, the metaphysis and a zone of epiphysis underlying the articular cartilage and the fovea capitis (Figs. 13 to 15). Most of the epiphysis is occupied by inactive yellow fat. Frequently we have seen a sharp line of demarcation between the two differently coloured marrows of epiphysis and metaphysis and the junction is a reminder

of the situation the growth plate previously occupied.* In those specimens in which the metaphysis is only partly occupied by red marrow this striking partition is, of course, not seen. These findings are curiously at variance with many statements in the literature which localise the red marrow to the epiphysis or to the proximal portions of the adult femur.

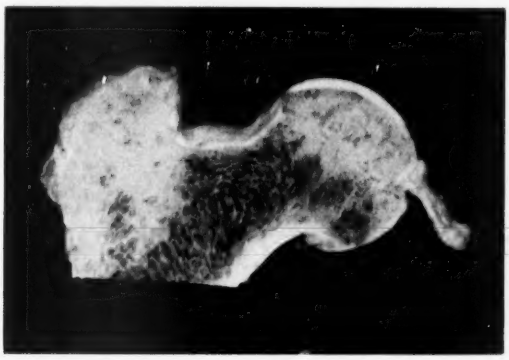

FIG. 13

FIG. 14

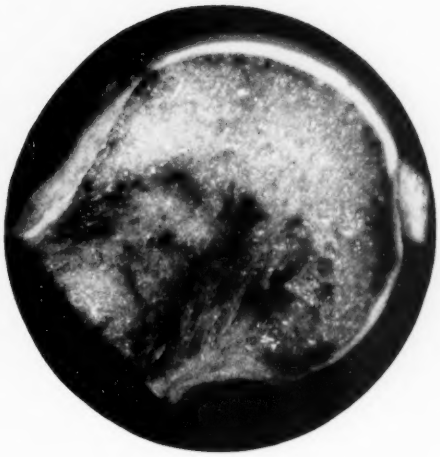

FIG. 15

Coronal sections of femoral heads. The epiphysis is largely occupied by yellow marrow and the metaphysis by red. Figure 13—Femoral head of a subject aged seventy-six. Figure 14—Femoral head of a subject aged fifty-six. Figure 15—Femoral head of a subject aged fifty-three.

Microscopically there is no clear-cut separation of the marrow into yellow and red; the two forms merge gradually into each other and there are an infinite number of marrow types ranging from the very cellular to the completely fatty. The red, cellular marrow consists of an argyrophil meshwork of reticular fibres attached to which are reticular cells. Within this mesh are found a great variety of blood corpuscles showing all degrees of development, occasional fat cells and the highly characteristic spacious thin-walled blood vessels, the

* We are aware that some of the specimens in which this observation was made may not come within the limits of strict normality in that the main or contributory cause of death may have provoked some increased haemopoiesis. Nevertheless the findings illustrate the individuality that the metaphysial marrow can show in its haemopoietic activity.

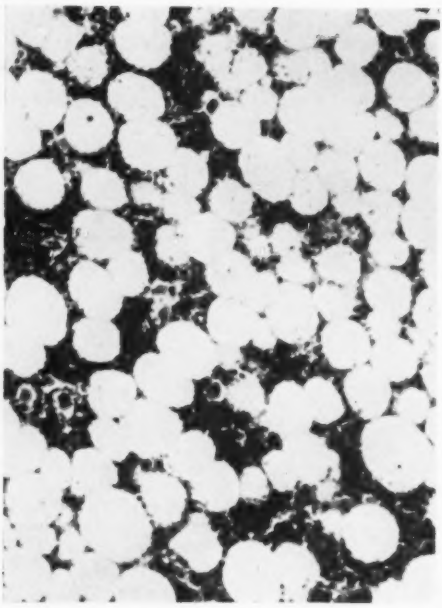

FIG. 16

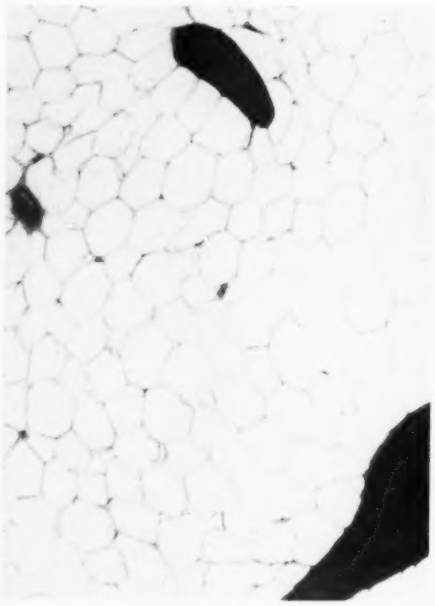

FIG. 17

Photomicrographs of sections of the bone marrow 10μ thick. Figure 16—The red marrow (×105). Figure 17—The yellow marrow (×70). The difficulties of determining vascular arrangements in these types of preparation are obvious.

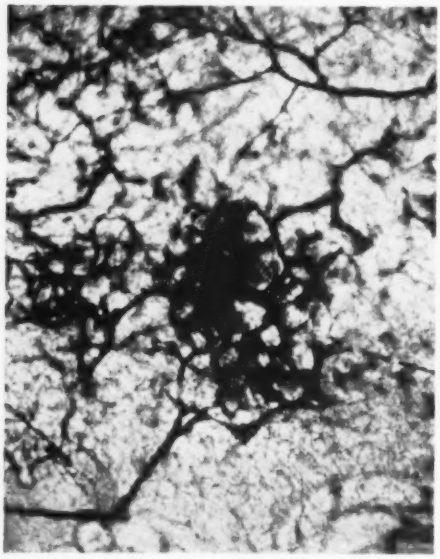

FIG. 18

FIG. 19

Photomicrographs showing the vessels within the haemopoietic marrow (Fig. 18) and the fat marrow (Fig. 19). In both, an afferent vessel enters the field at the bottom left-hand corner. Injection mass, Berlin Blue; unstained sections 400μ thick. Figure 18—The afferent vessel ends in the anastomosing meshwork of the sinusoidal bed (×45). Figure 19—The afferent vessel distributes capillaries which run between the lobules of fat cells; sinusoids are absent. The large irregular vessel running to the bottom right-hand corner is a vein whose tributaries are coming from the capillary bed (×75).

venous sinusoids (Fig. 16). In the yellow marrow (Fig. 17) fat cells have replaced practically all these other types; scattered between the fat are small blood vessels of capillary size.

The arterioles of the marrow are singular in appearance in that throughout their course they undergo little or no decrease in calibre and their branches are approximately the same size as themselves; in their passage through the marrow they pursue a straight course, changing direction by sudden angulations. The blood conveyed by the arterioles eventually reaches one of the two available destinations, either the sinusoidal circulation of the red marrow (Fig. 18) or the capillaries of the fat marrow (Fig. 19). The fine-walled vessels of the haemopoietic areas, wherever they may be within the bone, take the form of the sinusoids (Figs. 20 to 22). These combine to form an irregular bulging and profusely anastomotic network which is found to correspond to the lobules of the red marrow; several precapillary vessels bring blood from various directions to each clump of sinusoids. Although the sinusoids are many times the size of ordinary capillaries their walls are as thin as the capillary wall. We have not found any evidence of an open circulation due to fenestrae in the sinusoidal wall, although it must be noted that the collections of injection material which we have accepted as extravasation due to rupture of the vessel wall have always occurred within the sinusoidal meshwork (Fig. 23).

The capillaries lying between the fat cells of the yellow marrow (Figs. 24 and 28) are similar to capillaries in other tissues. They arise from precapillary arterioles and drain into venules, and this type of circulation is also found scattered throughout the red marrow in those parts where fat cells are present in addition to the haemopoietic elements. In the capillary network the point of union of one capillary with another is frequently marked by a conical enlargement of the otherwise narrow lumen.

The many variations in the cytology of the marrow alluded to above are paralleled by the variations in the vascular picture; the capillaries and sinusoids are not only continuous but every grade of their admixture and partition is seen.

The relationship of the articular cartilage to the blood vessels of the bone—Normal articular cartilage is avascular, but in two situations it comes into contact with capillary vessels: on its deep attached surface and at its peripheral margin. The basal layers of the cartilage which are apposed to the underlying bone are calcified and the subchondral bone does not form an absolute barrier isolating this tissue from the circulation within the femoral head. Precapillary vessels arising in the marrow pass through canals in the subchondral bone (Figs. 25 to 27) and form single broad capillary loops at the deep surface of the calcified cartilage; post-capillary venules return from these loops through the canals to the marrow. This single capillary system regularly arranged against the deep surface of the cartilage is different from anything else seen within the marrow circulation and appears to be specific to the chondro-osseous junction. We have been unable to determine any specific arrangement of capillaries in the subsynovial tissues at the circumference of the normal articular cartilage.

The veins—Our knowledge of the venous anatomy is as yet incomplete. The venous radicles coming from the capillaries (Fig. 28) and the sinusoids are broader and run a more irregular course than the equivalent arteries. In certain zones, such as the inferior metaphysial region, venules draining the sinusoids empty quickly into capacious thin-walled veins (Fig. 29); elsewhere veins of a smaller calibre commonly follow the course of an artery either alone when they may spiral around the latter (Fig. 30) or in association with another vein, one on each side (Fig. 31). In cross-section the larger veins which are soon to leave the head present a characteristic elliptical appearance as they lie adjacent to the artery in the fibrous sheath previously referred to (Fig. 5).

In our material certain observations made after injecting consecutively two materials differing both in colour and particle size have led us to suspect the existence of arterio-venous anastomoses within the bone. We have not so far been able to demonstrate these to our complete satisfaction.

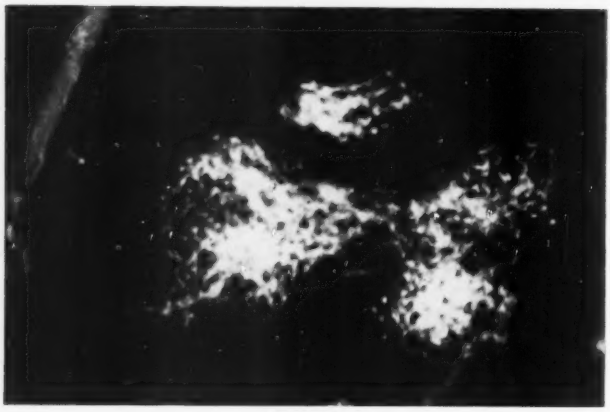

FIG. 20

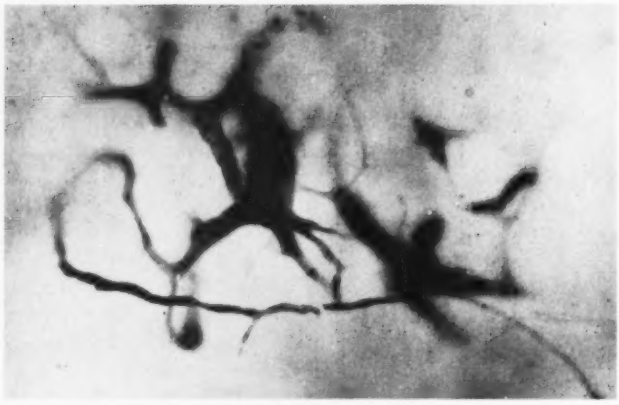

FIG. 21

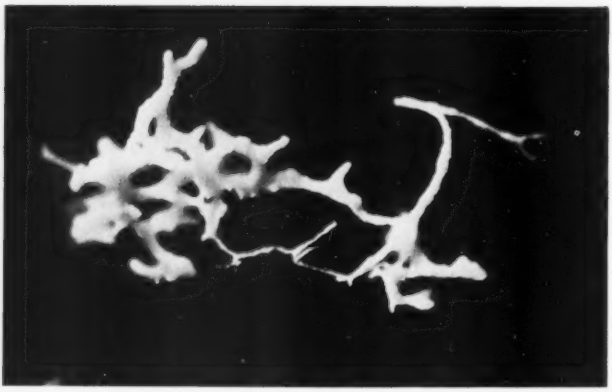

FIG. 22

The sinusoids of the haemopoietic marrow. Figure 20—Radiomicrograph showing four groups of sinusoids. The vessel on the left of the field is an artery. Injection mass, barium (×18). Figure 21—Photomicrograph showing an afferent vessel leading into a sinusoid. Injection mass, Berlin Blue. Unstained section 400μ thick (×174). Figure 22—Photomicrograph of a Neoprene cast of sinusoids (×50).

FIG. 23

Angiogram of a coronal slice of a femoral head, subject aged seventy. The irregular opacities within the metaphysis are mostly areas where sinusoids of the red marrow have in part been filled and extravasation has then occurred. Injection mass, barium.

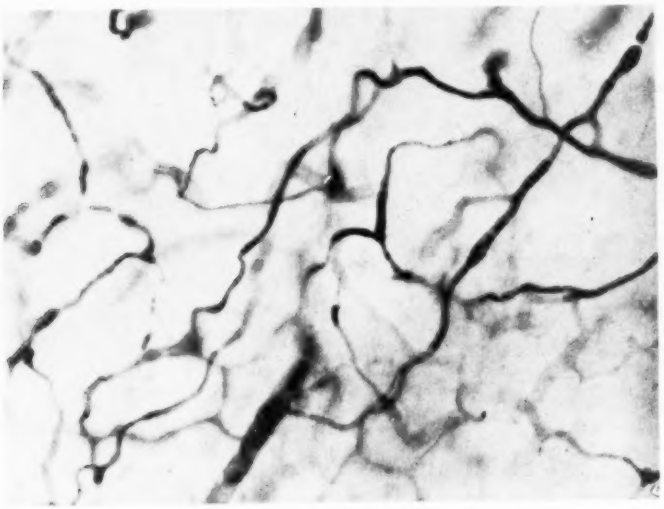

FIG. 24

Photomicrograph of capillaries within the fat marrow. Injection mass, Berlin Blue. Unstained section 400μ thick (× 174).

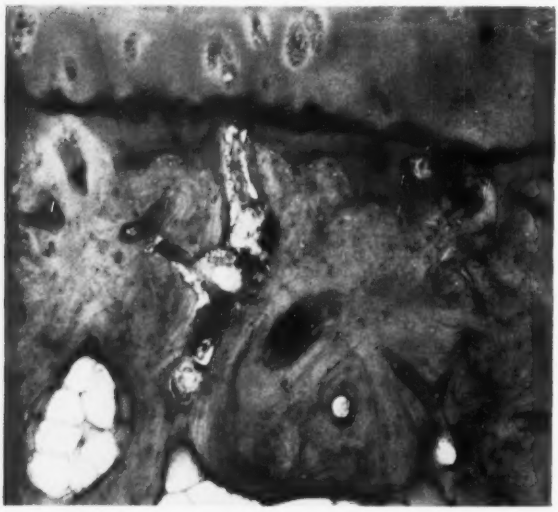

FIG. 25

FIG. 26

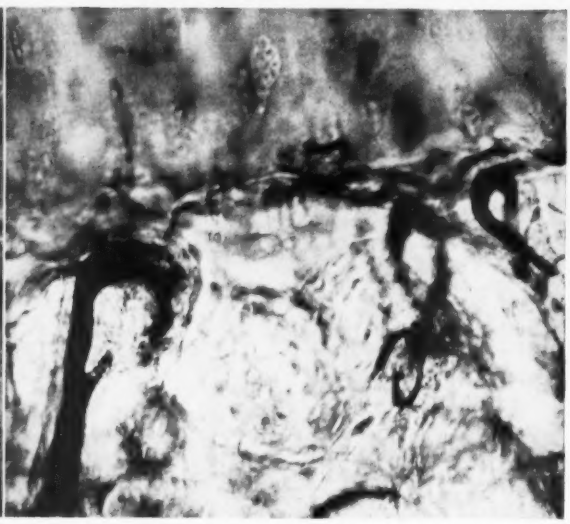

FIG. 27

Juxta-chondral blood vessels. Figure 25—Photomicrograph of the junction of articular cartilage and bone. Canals in the subchondral bone lead up towards the calcified layer of the cartilage. The irregular horizontal wavy dark line marks the superficial border of the calcified cartilage (H.E. × 70). Figures 26 and 27—Two fields from a different specimen showing the junction between the articular cartilage above and the bone below. Four vessels pass up through the subchondral bone to the calcified cartilage, whose irregular upper border can be distinguished despite the unstained nature of the section which is 400μ thick. Injection mass, Berlin Blue (× 210).

DISCUSSION

We have emphasised that throughout maturity and even in old age we have been unable to detect any decrease in the richness of the arterial tree within the femoral head, and the only explanation we can offer for the many statements to the contrary that exist in the

literature (Langer 1876, Walmsley 1915, Lang 1916, Kolodny 1925, Cheynel 1947 and Etienne and Granel 1949) is that these are based on technical errors and the wrong interpretation of negative findings. This integrity of the circulation in the older subjects is particularly noteworthy in relationship to the cartilage degeneration and other features of osteoarthritis which are encountered in joints increasingly commonly with advancing age (Heine 1926, Bennett *et al* 1942). In the course of another work we have confirmed the occurrence of these changes in the hip joint. The present report suggests that they are not preceded or accompanied by any general ischaemia within the femoral head. The marked changes in the vascular pattern which we have found to accompany the various stages and lesions of osteoarthritis will be detailed in a subsequent paper.

The lifelong persistence of the epiphysial arterial pattern, with the predominance therein

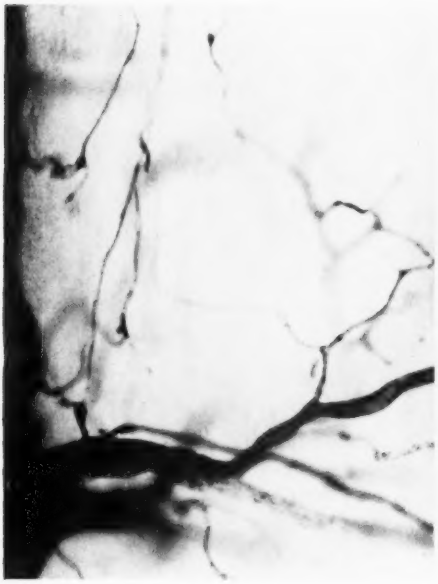

FIG. 28

FIG. 29

Venous drainage of the marrow. Figure 28.—Photomicrograph of the fat marrow showing capillaries draining into a venule in the lower portion of the field. This vessel proceeds into a vein. Injection mass, Berlin Blue. Unstained section 400μ thick (×123). Figure 29.—Photomicrograph of the red marrow showing sinusoids in the top half of the field being drained by short venules into the large vein inferiorly. Injection mass, barium. Unstained section 400μ thick (×34).

of the lateral epiphysial arteries, may increase our understanding of one of the main factors responsible for the greater incidence of necrosis of the femoral head after unimpacted adduction fractures of the femoral neck when compared with abduction fractures. In the former variety the lateral epiphysial arteries are lying at the site of the greatest tearing of the tissues, whereas in abduction fractures these important vessels are not subjected to the same risk of injury.

The nutrition of cartilage has been the subject of an immense amount of research and is still an unsolved problem. The present study brings a contribution to this, in that it has revealed the form of a capillary system which appears to be directed towards the cartilage; the anatomical pathway for the conveyance of nutriments from the subchondral circulation to the cartilage can be said to exist. The canals in the subchondral plate and their termination

close to the calcified zone of the cartilage can be seen in ordinary histological preparations of uninjected material, as has been recently emphasised by Holmdahl and Ingelmark (1950).

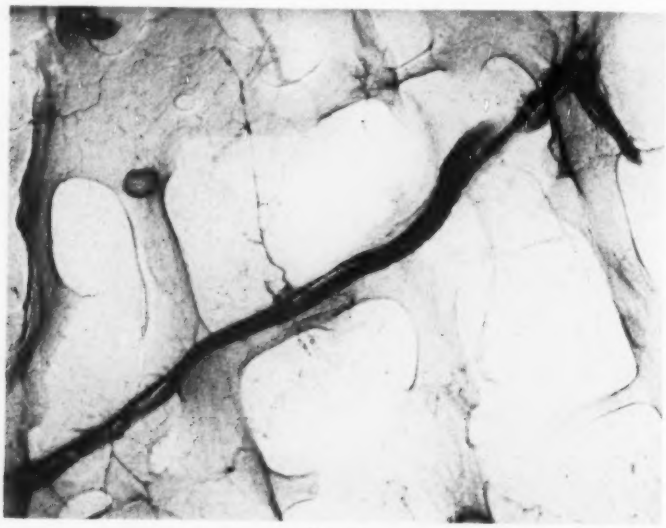

FIG. 30

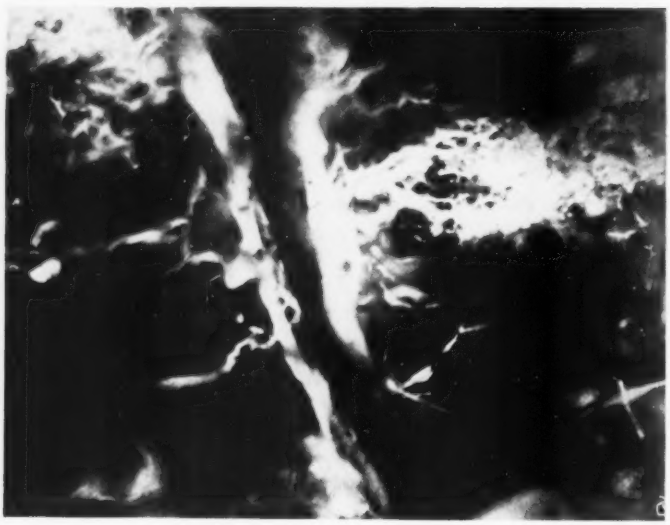

FIG. 31

The course of the veins. Figure 30—Photomicrograph. A single broad vein describes a gentle spiral around a slender artery. Injection mass, Berlin Blue. Unstained section 400μ thick (×30). Figure 31—Photomicrograph showing two white venae comites, filled with barium, on either side of an artery filled with Berlin Blue. Sinusoids are seen draining into the vena comes on the right of the artery. Spalteholz preparation (×18).

Arteries of spiral form are seen frequently in our material. They are invariably present in the synovial membrane; other sites where their presence has impressed us by their frequency are the early intra-osseous course of the lateral epiphysial and the inferior

metaphysial vessels, the site of the old growth plate and to a lesser extent the centre of the metaphysis. It is uncommon to find them in any profusion in the epiphysis. Their occurrence in the synovial membrane and at the point of entry of the main trunks into the head might suggest that the spiral shape serves to adapt these vessels to the demands of joint movement; but this explanation cannot be applied to those spiral vessels located deep in the head. The proximity of these latter to the sites of red marrow formation invites the suggestion that some correlation could exist between vessel form—assuming this is not an injection artefact—and haemopoiesis. Reynolds (1948) working with the ovary, and Harrison and Weiner (1949) working with the testis, have considered the possible ways in which the spiral arteries associated with these organs could be related to the conditions necessary for the cellular proliferation that occurs there.

The description of the capillaries and sinusoids of the marrow which we have given is at variance with much that is to be found in the literature and we would suggest two reasons that might account for this. Firstly, previous investigators have worked mainly with animal tissues; and secondly, in the past, interpretations have been made from the study of thin microscopic preparations (less than 20μ); we have found these latter to be not only uninformative of vascular orientation but positively misleading. The finest anastomosing vessels within the fat marrow are true capillaries; the term sinusoid, coined by Minot (1899–1901) and first applied by Doan (1922) to the vessels of the haemopoietic marrow, seems to us an apt name in that it distinguishes these vessels from the capillaries within the fat. The sinusoids do not resemble capillaries morphologically nor does their form suggest the function inherent in the latter type of vessel.

Doan (1922, 1925), working with animal material, considered that the " venous sinusoids form normally the principal functioning vascular bed for the actively circulating blood in the marrow; *i.e.*, they correspond largely to the capillaries of other organs." By the use of a special starvation technique he rendered the marrow of the pigeon hypoplastic, and then was able to demonstrate therein " a most extensive system of capillaries, hitherto unsuspected." He believed that these latter vessels were not connections between arteries and veins but ran from sinusoid to sinusoid, which structures they entered with a conical enlargement of their lumen; that this capillary bed was normally non-patent and functionally dormant as far as the active blood circulation was concerned; and that in the epiphysis the capillaries surrounded each fat cell. We have enumerated here the differences between the occult circulation described by Doan and the one that we have constantly found to be present and patent within the normal fat marrow; we have not seen in our material a collapsed intersinusoidal capillary bed such as Doan described. He believed that these capillaries were the site of erythropoiesis and that they might be thrown open to the circulation under conditions of increased activity of the marrow, as in anaemia (see below). Whatever their haemopoietic potentialities may be, we judge from their distribution and morphology that the capillary bed described above by us is responsible for the metabolic needs of the cells of the fat marrow.

We have described how the distinction between the vascular epiphysis and metaphysis can be made in the adult and that one of the hallmarks of the epiphysis is the arching arterial pattern. We have also seen that the common association between this pattern and the fat marrow of the epiphysis is not unchangeable. The constant association between vessel form and marrow type is found only in the finest ramifications of the arterial tree. Here the capillary net is the vascular counterpart of yellow marrow, the sinusoids of the red. This is well demonstrated in states of anaemia, in which the increased demand for red blood cells results in the transformation of the epiphysial marrow from yellow to red. The arterial arch pattern of the epiphysis is unchanged in such circumstances but the capillaries of the previously fatty marrow are replaced by sinusoids. Since there are, at this level of the circulation, only two types of vessel, the capillary and the sinusoid, we are unable to escape

the conclusion that such extension of the haemopoietic tissues is accompanied by the conversion of capillaries into sinusoids.

While it is dangerous to base speculations concerning function on morphological appearances, it seems likely to us that as the slender afferent vessels debouch into the capacious sinusoids the rate of blood flow therein must be severely slowed. The sluggish circulation which would thus obtain might in part be responsible for the arrest and localisation of metastatic tumour deposits and certain infections within the bones.

SUMMARY

1. The form and distribution of the blood vessels within the adult human femoral head are described.

2. It has been found possible to delimit the proximal femoral epiphysis in mature years by reference to arterial form alone.

3. Two morphologically different sets of vessels are described interposed between the arterioles and venules of the bone marrow. One, a true capillary bed, lies mainly within the fat marrow; the other, constituted by sinusoids, lies within the red marrow. The departure of these findings from current views is noted.

4. A capillary system is described in relationship to the calcified zone of the articular cartilage.

5. No evidence has been found in support of the common belief that the circulation within the femoral head decreases quantitatively with advancing age.

It is a pleasure to acknowledge the help we have received from many people in the course of this investigation. In particular, Dr G. M. Ardran, of the Nuffield Institute for Medical Research, Oxford, has not only provided all the radiographic facilities but has frequently given us his advice on the interpretation of results. Dr F. Schajowicz, of Buenos Aires, working in this centre for four months made available to us the full extent of his knowledge of the minute anatomy of the locomotor system. He introduced many valuable histological and microphotographic techniques and it was he who first pointed out to us the partition of the marrow described above. We are, however, most indebted to him for his never failing enthusiasm. We are grateful to Dr Robb Smith, Director of Pathology, Radcliffe Infirmary, Oxford, and Dr Cosin, Director of Cowley Road Hospital, Oxford, for the post-mortem facilities which they have extended to us. Lastly we would like to thank the staffs of the Photographic Department and the Pathological Laboratory of this centre, and in particular Mr Hill, our laboratory technician, for his invaluable help with every technical process involved in this investigation.

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THE BLOOD SUPPLY OF THE FEMORAL SHAFT

An Anatomical Study

P. Gowans Laing, Pembury, Kent

It is axiomatic that the surgeon must possess a detailed knowledge of the anatomy of the part on which he is to operate. In spite of the recent popularity of open reduction in the treatment of the fractured femoral shaft, little information is available on the details of its blood supply. Since the success of these operations depends, to a large extent, on a minimal interference with the blood supply of the bone the anatomy of the nutrient vessels is of considerable consequence. It was therefore decided to investigate the details of the blood supply of the femoral shaft.

HISTORICAL REVIEW

The first detailed account of the blood supply of the femur was given by Lexer, Kuliga and Turk (1904) in the course of a description of the supply of all the bones. These workers injected the arterial systems of newborn and adult post-mortem subjects with a mercury-turpentine emulsion and then took stereoscopic radiographs of the specimens. They also investigated the problem in a similar manner in amputation specimens. Lexer *et al.* found evidence of four main arterial systems supplying all long bones. These were namely: periosteal, diaphysial, metaphysial and epiphysial systems. The diaphysial or nutrient arteries supplying the femur were stated to be two in number and to enter the shaft of the bone in the region of the linea aspera. In children the superior vessel passed through the cortex in a downward direction and the inferior one in an upward direction. In adults both vessels are stated to pass through the cortex in an upward direction. These workers also state that the size of the arteries relative to the size of the bones decreases with increasing age.

The next detailed analysis of the problem was given by Anseroff (1934) as part of his researches into the blood supply of the long bones. This worker was only able to find evidence of three systems of nutrient arteries, namely, periosteal, diaphysial and epiphysial groups. With particular reference to the femur, Anseroff found that, although there were usually two nutrient arteries to the shaft, there was often only one. He also stated that the femora of children have more than two nutrient vessels in 23·6 per cent. of cases while the same is true in only 8·7 per cent of adults. When considering this statement it is important to appreciate the way in which these figures were obtained. Anseroff determined the numbers and the topography of the nutrient vessels by the direct examination of the surfaces of macerated young and adult bones. The sources of error in this method will be discussed later. This worker agreed with Lexer that the nutrient arteries of the femur always enter the bone in the region of the linea aspera. He stated that in the usual arrangement one artery enters the upper third of the femur and one enters the lower part of the middle third.

THE PRESENT INVESTIGATION

Material and methods—The blood supply of the femur was examined in ten adult and in seventeen newborn subjects. In each case the femoral artery was injected with an aqueous suspension of barium sulphate. Care was taken to avoid the use of great pressure because it was found that the suspension would then fill both the arterial and the venous systems. The limbs were then dissected to determine the source of the nutrient vessels to the femoral shaft. The femora were then removed from the limbs and all soft tissue and periosteum was cleaned off them. The adult specimens were radiographed in antero-posterior and in lateral views.

FIG. 1

FIG. 2

FIG. 3

Figure 1—Injected femur of a newborn infant. Two nutrient vessels are present. Note the venous foramina. Figure 2—Injected femur of a newborn infant. Both nutrient arteries ascend through the cortex. Figure 3—Injected femur of a newborn infant. Both nutrient arteries descend through the cortex.

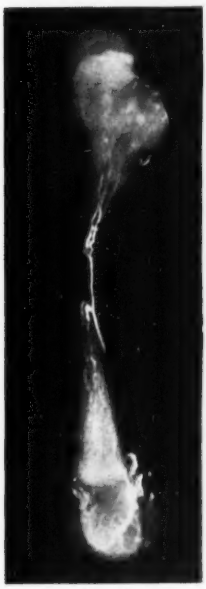

FIG. 4

FIG. 5

FIG. 6

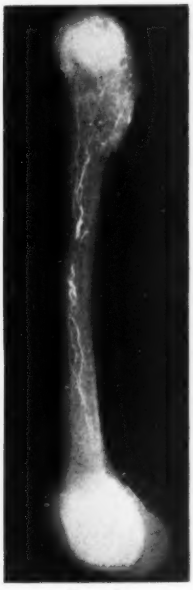

FIG. 7

Figure 4—Injected femur of a newborn infant. Only one nutrient artery is present. Note the long ascending intracortical course and the empty venous foramina. Figure 5—Injected femur of a newborn infant. Note the short ascending course of the single nutrient artery. Figure 6—Injected femur of a newborn infant. Note the short descending course of the stem of the single nutrient artery. Figure 7—Injected femur of an eleven months old infant. The short nutrient stem is nearly horizontal.

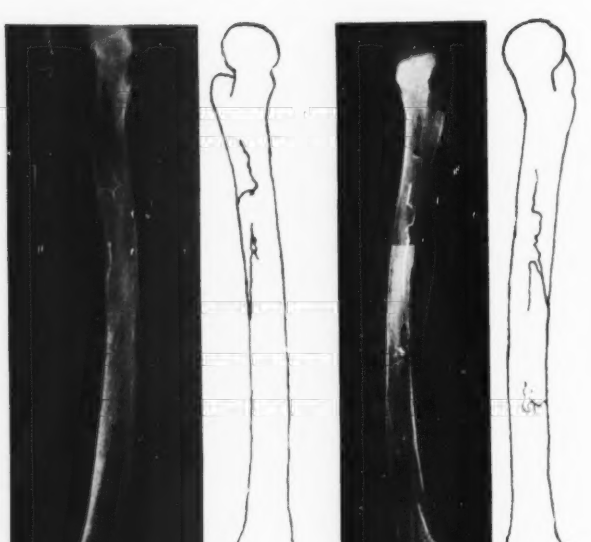

FIG. 8 FIG. 9

Figure 8—Injected adult femur showing two nutrient arteries, both entering the upper half of the shaft. Three out of ten adult femora examined were of this type. Figure 9—Injected adult femur showing two nutrient vessels. Note low position of the inferior nutrient. The large opacities were produced by rupture of small arteries. In only this one adult femur did a nutrient vessel enter the lower third of the shaft.

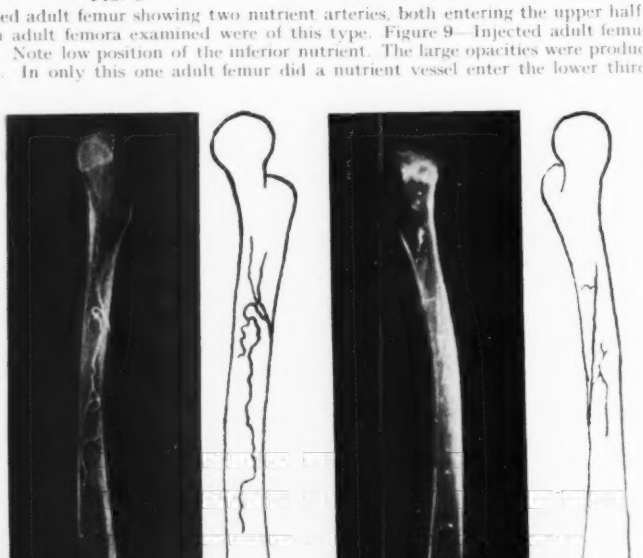

FIG. 10 FIG. 11

Figure 10—Injected adult femur showing one nutrient artery having a short transcortical course in the upper part of the bone. Five out of ten adult femora examined were of this type. Figure 11—Injected adult femur showing one nutrient artery having a long ascending passage through the cortex. The scattered opacities were produced by barium leaking through ruptured vessels.

The bones from the stillborn and the newborn subjects were decalcified in 10 per cent nitric acid, neutralised in 10 per cent sodium carbonate and then radiographed. In the early stages of the investigation some of these smaller bones were not decalcified.

Findings—In all subjects the nutrient arteries arose as branches of one or other of the perforating branches of the arteria profunda femoris. In most cases the first perforating branch supplied one nutrient artery, usually the superior one, and the inferior nutrient arose from one of the remaining perforating vessels in an inconstant manner. In all cases the nutrient arteries entered the femoral shaft in the region of the linea aspera.

Seventeen femora from children under one year of age were examined. In eleven two nutrient arteries supplied the femoral shaft. The direction of these arteries through the cortex of the femur was found to vary. In eight cases the superior artery took a downward course until it reached the medullary cavity when it turned upwards, and the inferior one took an upward course through the cortex before turning downwards (Fig. 1). In two cases both arteries passed through the femoral cortex in an upward direction (Fig. 2), and in one case both took a downward course (Fig. 3).

In the remaining six children's femora only one nutrient artery supplied the shaft. In two of these the artery had a long ascending transcortical course (Fig. 4), and in one it had a short ascending course (Fig. 5). In two bones the artery had a short descending stem (Fig. 6), and in the last case, that of a child aged eleven months, the intracortical stem was short and horizontal (Fig. 7).

In the ten adult femora (Figs. 8 to 11) the nutrient arteries all passed through the femoral cortex in the region of the linea aspera and had an ascending course. The length of the transcortical course varied considerably from case to case.

In four bones two nutrient vessels entered the shaft and in three of these both arteries entered the upper half of the femur (Fig. 8). In one case (Fig. 9) the inferior artery was a small vessel and entered the lower third of the shaft while the superior one entered the middle of the shaft.

In six of the adult femora only one nutrient artery supplied the shaft. In five of these the vessel had a short transcortical course in the upper third of the bone (Fig. 10) and in one case (Fig. 11) the artery entered the cortex at the lower end of the middle third and had a long ascending passage through the cortex.

In all these cases the arteries branched as soon as they had reached the medullary cavity and these branches passed up and down the medullary cavity.

DISCUSSION

The findings presented here are not intended as a statistical analysis but are merely an indication of the variability of these nutrient arteries. It is obvious that a considerable number of femora have only one main nutrient vessel supplying the shaft. It is also notable that in most cases, even including the bones with two such vessels, no major artery entered the lower third of the shaft. In no case were more than two nutrient vessels found and it is possible that Anseroff mistook the quite large venous foramina of children for nutrient foramina. These can be seen in Figures 1 and 4 as quite separate entities, and are also seen in adults.

It thus emerges that the blood supply of the femoral shaft is in many ways similar to that of the tibial shaft which constantly has only one nutrient artery. The dangers of avascular necrosis in fractures of, and in operations on, the tibial shaft are too well known to bear repeating. From these experiences with the tibia we have learnt that, in the absence of the main nutrient artery, the epiphysial and periosteal arterial systems cannot always take over the nutrition of the lower fragment of the shaft and avascular necrosis or impaired osteogenesis results. A fracture through the junction of the upper and middle thirds of most of the femora investigated would have deprived the upper end of the lower fragment of its main blood

supply. It is of interest to calculate the effects of a fracture through the junction of the middle and lower thirds of the femoral shaft in cases having one nutrient artery with a long intracortical course (Fig. 12). As can be seen, this state of affairs would account for the cases of avascular necrosis of the lower end of the upper fragment occasionally met with in fractures of this type.

It is perhaps also worthy of note that the passage of a correctly fitting intramedullary nail in any one of the adult femora investigated would have destroyed most of the medullary branches of all the nutrient vessels in every case.

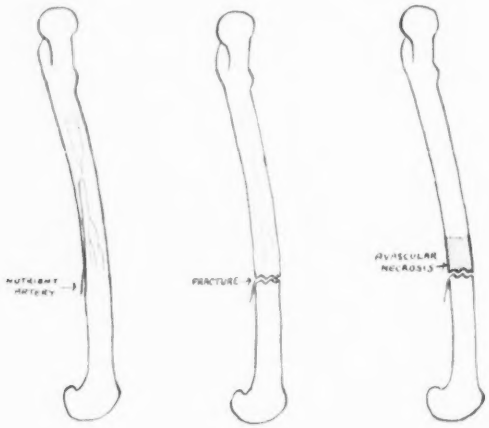

FIG. 12

Diagrammatic representation of the possible effect of a fracture on a femur with a single long nutrient artery.

The constancy with which the arteries enter the femoral shaft in the region of the linea aspera needs reiterating. It is obvious that the linea aspera should never be stripped of muscle attachments at operation. It is not quite so obvious that when plating the femur one should never put the plate on the anterior surface of the bone, for then the screws might well penetrate the linea aspera posteriorly and, if the femur in question has only one nutrient artery, could destroy the major source of blood to the shaft.

SUMMARY

1. Previous investigations into the blood supply of the femoral shaft are reviewed.

2. Details of the blood supply of the shaft of the femur in seventeen children under one year of age, and in ten adults, are given.

3. These findings are discussed with special reference to the fate of the femoral shaft after fracture or operation.

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AN INVESTIGATION INTO THE CORRELATION BETWEEN THE ELECTRICAL POTENTIALS OF METALS AND THEIR BEHAVIOUR IN BIOLOGICAL FLUIDS

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Menegaux, Odiette and Moyse (1934) studied the influence of metals on the growth of osteoblasts and fibroblasts in tissue cultures and concluded that the toxicity of metals was the chief factor in retarding growth. Carney and Burch (1942) studied the weight loss of tantalum in dogs and concluded that the metal was well tolerated by tissue. Fink and Smatko (1948) investigated the weight loss of vitallium and stainless steel plates in various fluids and stated that no gross changes in weight were observed. Von Baeyer (1908) studied the reaction of tissues to metals and noted that metallic particles were set free and could be identified in the surrounding tissues. Orsós (1925) noted that an electric current is generated when two dissimilar metals are placed in the body. Venable and Stuck (1938) attributed inertness of metals to electro-chemical stability and concluded that the current flow registered by a microammeter, with the metals under test in a solution of physiological saline, was a satisfactory criterion of the degree of tissue reaction that might be expected. Pervès and Damany (1938) measured the potentials between various plates and screws immersed in serum. Key (1941) studied corrosion by placing the test metals in salt solution kept at 58 degrees centigrade. Bothe, Beaton and Davenport (1940) and Bothe and Davenport (1942) measured the electrical potentials between metallic implants and concluded that bone reactions were not closely correlated with the potential differences but remained characteristic for a given metal or alloy. Cauchoix and Lavarde (1950) in investigating the use of zirconium measured the electro-motive force of polarisation of various metals, and Bates (1950) in a similar investigation measured the current passing between a specimen of the metal and a calomel electrode.

There are two main theories on the subject of the reaction of tissues to metals. The first is that the whole question is an electro-chemical phenomenon, the second that the matter hinges on the question of toxicity. Both theories may be partly right. A metal that does not corrode at all will remain quite inert in tissue, as none of its ions will pass into solution, and it will exert no influence beyond the monolayer where it is in contact with its living medium. At the same time, if a metal corrodes at all, its effects will vary with the weight of ions passing into solution and the toxicity of those ions.

It was decided to study the question of corrosion as this phenomenon has already been intensely investigated and shown to be electro-chemical in nature. The whole question is gone into most thoroughly by Evans (1946) and Uhlig (1948) who give many references to the original literature. It is not proposed to review the literature here, because most of the experimental methods evolved are not applicable to our problem. In the first place, most of the investigations of corrosion have been carried out with inorganic fluids such as sea water or dilute acid—substances far simpler than those pervading living tissue—and it seems also that the presence of lyotropic colloids, oxidase-reductase systems and reducing agents such as glucose may modify the simple reaction between metallic ions, chloride ions and oxygen. In addition to this many of the methods devised are applicable to one class of metal only (for example the stainless steels) whereas a method is needed that can be applied to

any metal, element or alloy. For this reason we decided to start the investigation from the beginning instead of trying to adopt one of the existing electro-chemical techniques.

Three metals—tantalum, vitallium and 18/8 SMO steels—have found clinical application, though experiments have suggested that certain others, such as platinum, gold, titanium and zirconium may be inert in tissues. In industry to-day a great variety of metals is employed, any of which might be suitable for surgical purposes, but before they could be used clinically exhaustive animal experiments would be necessary. Whereas it is quite practicable to test some half-dozen metals *in vivo*, the expense and effort necessary to test a large number would be quite prohibitive. We therefore decided to attempt to evolve a simple *in vitro* method of "screening" all available metals with a view to selecting those most likely to be of service. Starting with the premise that the metals referred to above are more inert than others, it was our plan to find some measurable quantity whereby the degree of tissue reaction could be assessed before proceeding with *in vivo* experiments.

EXPERIMENTAL METHOD AND OBSERVATIONS

The measurement of the static potential between a piece of the test metal and a calomel electrode placed in equine serum gave a series of readings that bore no relation to the known inertness of metals. Also, figures obtained from weight loss in electrolysis, from the potential difference for unit current density between two pieces of the same test metal in serum, and from the anodic and cathodic potentials of such metals measured against a calomel electrode in serum were likewise unsatisfactory (Clarke 1953).

It was found, however, that the "anodic back EMF" (ABE) obtained by measuring the potential difference for known currents across an electrolytic cell formed by a calomel electrode as cathode and a rotating rod of the test metal as anode, in a bath of equine serum at 37 degrees centigrade, and subtracting the "IR drop," corresponded closely with the known inertness of the metal (Clarke and Hickman 1951). This ABE is independent of current over a wide range, as can be seen from Table I which shows typical results for silver.

Although this ABE appeared to be the measurable quantity for which we had been looking, there were some disadvantages to this method of measuring it. Three quantities—potential, resistance and current—had to be measured, each providing a possible source of

TABLE I

SILVER: ANODIC BACK EMF (ABE)

V (millivolts)	I (milliamps)	$V^1 = IR$	$V - V^1$ (ABE)
500	1·2	384	116
666	1·73	555	111
844	2·3	736	108
968	2·7	865	103
1,064	3·0	960	104
1,198	3·4	1,092	106
			Average 108

error. Two calculations had to be performed in order to obtain the figure required. In addition to this, the current had to be kept flowing through the cell while the valve potentiometer was being adjusted. This tended to lead to polarisation, and necessitated longer rests between readings.

In order to obtain the ABE as a direct reading the circuit shown in Figure 1 was devised. Switch S_1 is first placed in position 1. The cell HAC now forms one arm of a bridge, of which the other arms are the resistance box R_1 and the equal resistances R_4 and R_5. Using alternating

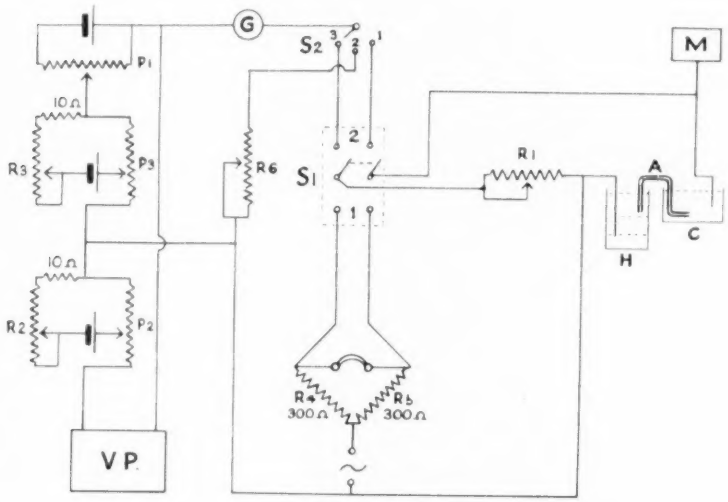

FIG. 1

Direct reading circuit for measurement of "anodic back EMF."

TABLE II

STEELS: ANODIC BACK EMF (ABE)

Identification	Major constituents								Potential (millivolts)
	Cr	Ni	Mo	Mn	Cb	Ti	Cu	V	
254	18·0	18·0	3·75	·80	—	·60	2·4	—	550
E.M.B. 3 T	18·0	8·0	3·25	·30	—	·30	—	—	500
S.F. 35	18·26	8·66	2·73	·46	—	—	—	—	480
E.M.B.	18·0	8·0	2·75	·50	—	—	—	—	480
B.B. 2 K	17·1	11·8	2·30	·73	—	·25	—	—	480
18·8 SMo	17·0	10·0	2·4	—	—	—	—	—	480
E.M.L.	18·0	9·5	1·25	·30	—	—	—	—	470
B.B.M.K.	18·0	18·7	2·09	·78	·56	—	2·03	—	380
E.S.T.	18·0	8·0	—	—	—	—	—	—	300
Weldanka "B"	19·2	10·5	—	·67	—	·70	—	—	300
E.D.P.	18·0	8·0	—	·40	—	·60	—	—	300
E.S.L.	19·0	10·0	—	·40	—	—	—	—	300
E.C.B.	18·0	10·0	—	·40	1·2	—	—	—	300
D.D.Q.	12·5	12·5	—	1·0	—	—	—	—	250
S.F. 22	17·98	8·26	·045	·56	—	·32	—	—	230
O.B.K. 1	18·0	7·94	·09	·5	·20	—	—	—	230
E.M.S.	18·0	10·0	·28	1·6	—	·60	—	—	220
ANKA "H"	17·8	17·8	—	·32	—	—	—	—	210
S.F. 21	14·22	11·93	—	·59	—	—	—	—	150
ANKA "M"	12·2	11·9	—	·58	—	—	—	—	120
S. 80	16·5	2·5	—	·20	—	—	—	—	90
S.F. 17	17·24	·52	—	·42	—	—	—	—	80
F.L. 17	17·0	—	—	·20	—	—	—	—	75
S.F. 11	13·10	·51	—	·47	—	—	—	—	50
F.G.	13·5	—	—	·25	—	—	—	—	40
MAK 1	12·95	·14	·01	·25	—	—	Tr	Tr	40
M.B.K. 1	13·69	·20	·01	·28	—	—	Tr	Tr	20
3% Ni-Steel	—	3·06	—	·50	—	—	—	—	320
Tormanc	·045	·055	·01	1·55	—	—	—	—	350
Mild Steel	·01	Tr	—	·66	—	—	Tr	—	480
Iron	—	—	—	—	—	—	—	—	500

current, the bridge is balanced by adjusting R_1 until no sound is heard in the receivers, when R_1 will equal the resistance of HAC. Switch S_1 is now placed in position 2, and switch S_2 in position 1. Potentiometer P_1 is adjusted to send a current through the milliammeter

TABLE III

NON-FERROUS METALS: ANODIC BACK EMF (ABE)

Metal	Identification	Potential (millivolts)
Titanium	—	3,500
Niobium	—	1,850
Tantalum	—	1,650
Platinum	—	1,450
Palladium	—	1,350
Rhodium	—	1,150
Iridium	—	1,150
Gold	—	1,000
Cr-Ni-Mo Alloy	Vinertia "C"	880
Cr-Ni-Mo Alloy	Langalloy "5R"	875
Chromium	Crystalline	750
Cr-Co-Mo Alloy	Virillium	750
Cr-Co-Ni Alloy	Vinertia "S"	750
Cr-Co-Ni Alloy	A 216	730
Cr-Co-Ni Alloy	A 189	700
Cr-Co-Ni Alloy	A 175	700
Cr-Co-W Alloy	P 4	700
Cr-Co-Mo Alloy	Vitallium	650
Cr-Co-Mo Alloy	Svedion	650
Bismuth	—	450
Ni-Cr-Fe Alloy	Nimonic "75"	350
Ni-Cr-Fe Alloy	Inconel	350
Zirconium	—	320
Ni-Cr-Fe Alloy	Nimonic "D"	250
Nickel	—	200
Ni-Cr-Al-Mo Alloy	C 26	160
Tungsten	—	120
Silver	—	110
Cu-Ni Alloy	O.J.U.	100
Cu-Ni Alloy	N.R.U. —1	60
Molybdenum	—	—20
Cu-Ni Alloy	70—30 A	—20
Copper	—	—30
As-Al Brass	N.T.G.	—50
Tin Bronze	N.V.T.	—60
Vanadium	—	—70
Al-Bronze	OYA 1	—80
As-Al Bronze	OYB 1	—80
Tin Bronze	N.V.W.	—90
Nickel Silver	—	—100
Admiralty Brass	B.A.Z.F.	—100
Arsenical Brass	E.B.W.	—100
Brass	—	—110
Tin	—	—200
Antimony	—	—250
Ni-Mo-Fe Alloy	Langalloy "4R"	—300
Ni-Mo-Fe Alloy	Alloy "B"	—330
Cobalt	—	—350
Indium	—	—400
Al-Cu Alloy	Duralumin 127	—500
Aluminum	—	—600
Cadmium	—	—650
Al-Mg Alloy	—	—650
Zinc	—	—950
Manganese	—	—1,080
Magnesium	—	—1,550

G and the cell HAC. As soon as the needle is steady, the reading is noted, and switch S_2 is moved to position 2. Current now flows through R_6 instead of HAC. R_6 is adjusted until the same current is flowing (which means that the potential across R_6 is the same

as the original potential across HAC) and the potentiometer P_2 is adjusted until the valve potentiometer reads zero—that is, an equal and opposite potential is applied.

Switch S_2 is now moved into position 3. The current now flows through the resistance R_1, which is equal to HAC. If there were no " back EMF " the current would remain the same. However, as this is not so, the galvanometer will show a larger (or smaller) current. The potentiometer P_3 is now adjusted until the same current is flowing. The potential introduced

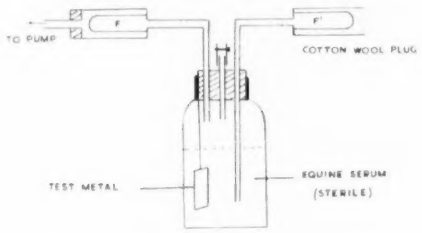

FIG. 2

Apparatus for finding weight loss of metals in serum.

by P_3 must now equal the " back EMF " of the cell, and is read directly on the valve potentiometer. The resistance R_2 and R_3 act as rough adjustments to P_2 and P_3. Results obtained by this method are shown in Tables II and III.

TABLE IV

LOSS OF WEIGHT OF METALS IN SERUM (EQUINE)

Metal	Weight loss (mgm./sq. cm.)	Anodic back EMF (ABE)
Tantalum	Nil	+ 1,650
Platinum	Nil	+ 1,450
Vinertia " C "	Nil	+ 880
Vitallium	Nil	+ 650
FMB 3T (Steel)	Nil	+ 500
Zirconium	Nil	+ 320
FST (Steel)	Nil	+ 300
Nickel	0·17	+ 200
Silver	0·6	+ 110
Copper	1·0	− 30
Mild Steel	1·6	− 480
Zinc	2·0	− 950

In order to find out whether there was any correlation between this ABE and weight loss due to corrosion *in vitro*, the following experiment was carried out. A number of 250 millilitre wide-mouthed bottles were fitted up as shown in Figure 2. A weighed sheet of the metal under test was suspended in sterile equine serum, the bottles being immersed in a water bath at 37 degrees centigrade. Twice daily the bottles were shaken and aerated by means of a filter pump. The filters F and F[1] served to prevent the introduction of contaminants. After thirty days the metal was removed, washed, dried and reweighed. The results are shown in Table IV.

It will be seen that metals whose ABE exceeds +300 show no loss of weight under the conditions of the experiment, whilst others show a weight loss which increases with increasing negative ABE.

DISCUSSION

The accuracy with which the ABE can be found varies for different metals. With some, such as silver, the figure can be repeated with an accuracy of 10 millivolts. With others the constancy is not so good. The noble metals, such as platinum, tend to rise with increasing current density, and with time. Readings must be taken as soon as the needle is reasonably steady. But these inconsistencies do not affect the picture. Platinum always comes in the range 1,400–1,500, and the metals being spread out along a scale of over 3,000 millivolts do not show significant change in their positions for a possible error of 10 per cent.

In order to obtain reproducible results the following conditions must be adhered to: 1) The metal anode must have all sharp edges rounded off and be highly polished. It must be immersed in serum for at least twenty-four hours before readings are taken. 2) The current density must not be too great. We have found that currents of the order of 1 mA square centimetre give the best results. 3) Time must be allowed for the milliammeter to become steady but measurements must be taken as quickly as possible and a rest of several minutes allowed between readings.

Although most metals that we have tested give a reasonably constant value for the ABE, the case of lead is anomalous since the value mounts steadily with current density and with time. At low values it is −300, but rises to 1,400. In sodium chloride solution lead remains constant at −300, and preliminary experiments suggest that this increase in potential is due to the sulphate ions present in the serum. Work on this point is continuing. It is worth noting that lead shot embedded in tissue remains inert for long periods.

One of the most interesting points that came to light was the close relation between the ABE and the composition of stainless steel. This is shown in Table II. It will be seen that steels with 2 per cent or more of molybdenum show a much higher potential than others, and that the potential falls with decreasing percentages of chromium and nickel.

The ABE's given in Tables II and III have been obtained using equine serum. The results obtained using human serum (pooled), reconstituted dried serum (human), and heparinised whole blood (equine) show no significant difference in the value of the ABE. Although there were slight variations in the values of the ABE obtained using these biological fluids, the order in which the metals have been classified using equine serum remained unchanged.

SUMMARY

1. The literature dealing with the reaction of tissues to metals has been briefly reviewed and discussed.

2. It is suggested that the "anodic back EMF" of metals, under the conditions of the experiment, is a measurable electrical quantity which can be correlated with their behaviour in tissues.

3. Details of the method for obtaining this "anodic back EMF" are given.

4. A correlation between the "anodic back EMF" and the loss of weight due to corrosion *in vitro* has been demonstrated.

5. The inertness of eighty-seven metals has been classified by this method.

6. It must be emphasised that these results are based on *in vitro* experiments only. *In vivo* experiments are in progress and the results will be published in due course. Preliminary work suggests that there is some correlation between the ABE and the behaviour of metals in tissue (Hickman 1953).

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HISTORICAL SURGICAL INSTRUMENTS IN THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND (2)

W. E. Thompson, London, England

The collection of surgical instruments and apparatus in the museum of the Royal College of Surgeons of England has gradually been built up, by gifts and bequests, over the past 150 years. It seems that no attempt was made to classify the instruments until 1871, when a separate room was provided and Mr R. Williams, of Messrs Weiss and Son, undertook the work. In 1878 Mr Walter Pye, F.R.C.S., compiled a manuscript list giving names and numbers, and, in some cases, short details but no descriptions. Then, in 1912, Mr Alban H. G. Doran, F.R.C.S., was asked to prepare a descriptive catalogue. Into this task Mr Doran put the whole of his energy and profound scholarship, completing the work shortly before his death in 1927. A glance through the several volumes, in print or typescript, will enable one to see the enormous amount of research into medical literature and College records that has gone into its compilation. It is from this catalogue that the greater part of the information in these articles was obtained.

Fig. 13

Cerate case formerly belonging to William Long, F.R.S., Master of the College in 1800.

A cerate case (Fig. 13) of white metal covered in polished green shagreen was formerly the property of William Long, F.R.S., Master of the College in 1800. On the upper surface of the lid is a silver plate engraved with the initials "W. L." and crest, and the words "Mr Long, July 7th, 1818" in the handwriting of William Clift (first Conservator of the Museum, 1800–1842) are scratched on the under surface. The interior of the case is divided into four compartments, one of which is subdivided into three smaller cells. It was presented by Mrs Long in 1818.

A surgeon's pocket instrument case (Fig. 14), dating from about the middle of the eighteenth century, is made of white metal and polished green shagreen, the exposed metal

FIG. 14

Left—A surgeon's pocket instrument case (mid eighteenth century). *Right*—A cylindrical silver pocket case of surgical instruments (late eighteenth century).

FIG. 15

Mungo Park's surgical pocket case.

parts being silver plated. It contains two pairs of scissors (one having curved blades), dressing forceps, ear scoop and director, and a spatula for spreading ointments; three empty spaces held instruments that are now missing. This case formerly belonged to Mr Hector, of Birmingham, a schoolfellow and friend of Dr Samuel Johnson.

Another interesting case, of the late eighteenth century, is made of silver and completely cylindrical (Fig. 14). It contains a pair of scissors (each ring handle of which is jointed to facilitate packing), dressing forceps, spatula, two flexible probes, female catheter, fleam or gum lancet, and a hollow white metal rod with a ring at one end to hold a quill containing caustic; the opposite end of the rod bears a screw cap covering a receptacle for red oxide of mercury. The case was presented by G. L. Wood, who qualified M.R.C.S. in 1819, and was used by the father or grandfather of the surgeon to whom the donor was apprenticed early in the nineteenth century.

An historical surgical pocket case is the one which belonged to Mungo Park (1771–1806), the famous African explorer (Fig. 15). Mungo Park received his medical training first as an

FIG. 16

FIG. 17

Figure 16—Baron Dimsdale's lancet case of wood covered with shagreen.
Figure 17—Silver lancet case carried by a surgeon when imprisoned in the Black Hole of Calcutta.

apprentice to Mr Thomas Anderson, a surgeon of Selkirk, and then at Edinburgh University where he served three sessions. He presented the case to Sir Anthony Carlisle in 1805. Sir Anthony Carlisle gave it to Mr Bartley, surgeon of Mitcham, Surrey. His accompanying letter, now preserved in the Library of the College, reads: " I beg to thank you for your great kindness, skill and attention to Mrs Carlisle's unfortunate health. Allow me to offer you a small remembrance of me. It is the pocket case of instruments which belonged to Mungo Park and which he gave me for a professional memento. In using this case, think of both of us." It is signed " A. Carlisle " and dated April 6, 1816. Mr Bartley's daughter presented the case to the College in 1902. The case is of red leather and contains the following instruments: two pairs of steel scissors and a third angled pair with steel blades and handles of white metal, director with ring handle, steel spatula, abscess lancet, tenaculum, gum lancet, blunt-pointed curved bistoury, three-eyed probes, dressing forceps (now missing), blow-pipe and lead pencil. A first edition of Mungo Park's *Travels in the Interior Districts of Africa*, published in 1799, is in the College Library.

Other pocket cases preserved in the Collection include that formerly belonging to Sir David Dundas (1749–1826), Master of the College in 1804, 1811, 1819, and others that belonged to Robert Liston (1794–1847), Sir William Fergusson (1808–1877), Sir William Flower (1831–1899) (Conservator of the Museum, 1861–1884), purchased before he proceeded to the Crimea where he served as a surgeon during the war, and Thomas R. College (1796–1879), one of the founders of Medical Missions in the East, all the instruments having engraved silver

FIG. 18

Top—Cerebral knife used by Sir Rickman J. Godlee in the first operation for tumour of the brain.
Below—Abscess opener probably dating from the seventeenth century.

gilt mounts. In addition there are a case presented to Dr Metcalfe when he took his degree in medicine at Cambridge in 1760 and given to the Museum by his great-granddaughter in 1936; and part of the contents of a case belonging to Sir John Erichsen (1818–1896), President 1880, the leather case and some of the instruments having been destroyed by enemy action in 1941.

The Collection includes some interesting lancet cases. One belonged to Baron Dimsdale

(Thomas Dimsdale, M.D., 1712–1800). His lancet case, made of wood covered with polished green shagreen, contained two lancets (Fig. 16). On the case was originally pasted a printed note: "The fee of fees, however, was that received by Dr Dimsdale in 1768 for inoculating the Empress Catherine and her son at Petersburg. It consisted of £12,000 paid down, a pension of £500 a year for life, and a dignity of a Baron of the Empire." A manuscript note pasted on the case reads: "This [Baron Dimsdale's] lancet case was given by one of his

FIG. 19
John Abernethy's needles.

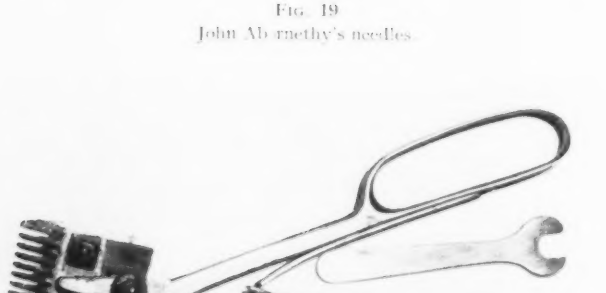

FIG. 20
Dr A. J. Balmanno Squire's hair clipper.

relatives to Mr Martin of Bewlay Cliff Cottage, N.W., who was a patient of mine and gave it to me. H. G. Knaggs." Dr Knaggs presented it to the Museum in 1894.

Another lancet case, in silver, contained four lancets, three of which are mounted in mother-of-pearl and the fourth in tortoise-shell. It belonged to John Rose, a surgeon of Eye, Suffolk, and was given to the Museum by Sir James Sherrington, O.M., in 1929 (Fig. 17). It originally belonged to a surgeon in India who was imprisoned in the Black Hole of Calcutta and had the case in his pocket at the time. His initials "T. J." are engraved on the lid.

An instrument of great historical interest is the cerebral knife used by Sir Rickman Godlee in the first operation for tumour of the brain, which was carried out at the Hospital for Epilepsy and Paralysis, Regent's Park, London, on November 25, 1884 (Fig. 18). The tumour was located as a result of the experimental work of Sir David Ferrier. Details of the case were published in the *Lancet* (1884). A dinner held to commemorate the jubilee of the operation was also reported in the *Lancet* (1934). The knife was presented by Sir Rickman J. Godlee, Bt., to the Museum in 1921.

An abscess opener probably dating from the seventeenth century is of particular interest (Fig. 18). It is preserved in a wooden case made to correspond to its shape with the spurs extended. The case is covered with leather with gilt marking and a falcon with head turned back. The letters " Gizl " with an " M " above and an " S " below are cut on the brass handle of the instrument. When the piston at the base of the handle is withdrawn the central pointed steel bar travels backwards along a groove in the steel guard plate and the spurs, one on each side, are drawn inwards to lie against it. The spring mechanism in the handle is held in check by pressure on a thumb-stud on the handle, and on release the steel bar flies forwards and the spurs outwards. This instrument was presented to the Museum in 1922 as a rare and ancient form of abscess opener. No history of its inventor or use had been obtained.

Packed in a sharkskin case, semicircular in shape, are three curved needles of a pattern seen in Savigny's *Instruments used in the Practice of Surgery* (1798) and a seton needle also illustrated in the same work (Fig. 19). These needles were given by John Abernethy to Mr Thomas Wormald (1802–1873), surgeon to St Bartholomew's Hospital.

The last instrument to be mentioned in this contribution is the hair clipper of Dr A. J. Balmanno Squire (M.R.C.S. 1858), presented by the makers, Messrs Weiss and Son, in 1881 (Fig. 20). It was devised for cutting off the hair of the scalp in skin diseases, and is said to be the first instrument of the kind invented.

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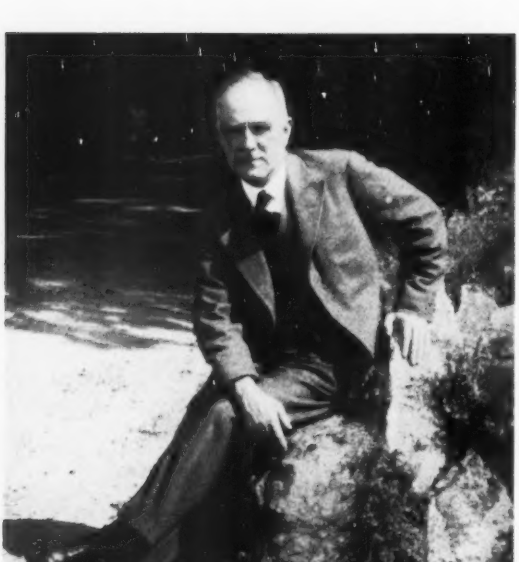


ALEXANDER MITCHELL

1881-1953

Alexander Mitchell came of medical stock; his father and grandfather had been country doctors practising from a village in Aberdeenshire, pleasant enough in summer but grim enough in the snows. Throughout his life he remained strongly attached to this part of the countryside, and to it he returned—a homing habit Aberdonians have. Another custom of the north-east, now alas too rare, was to give a boy destined for medicine a good general education first, and so at the age of twenty Mitchell graduated M.A. (with the old "seven subjects") in the University of Aberdeen. Qualification in medicine followed in 1905, and the higher degree in surgery (Ch.M.) in 1907. At first he practised in the country, although he did some surgery in Fyvie and in Elgin, cottage hospitals with a splendid record in the care of country folk; but by 1914 he had been appointed both to the Royal Hospital for Sick Children and to the Royal Infirmary in Aberdeen.

Experience in the Royal Army Medical Corps during the first world war strengthened his interest in orthopaedic surgery and on his return to Aberdeen it became his chief vocation, although he remained a general surgeon until 1936, when he took over the new orthopaedic unit in the Royal Infirmary. From this unit he developed the orthopaedic service of the north-east of Scotland, which he directed during and after the war. When he gave up surgery, he found an outlet for his energy in hospital management.

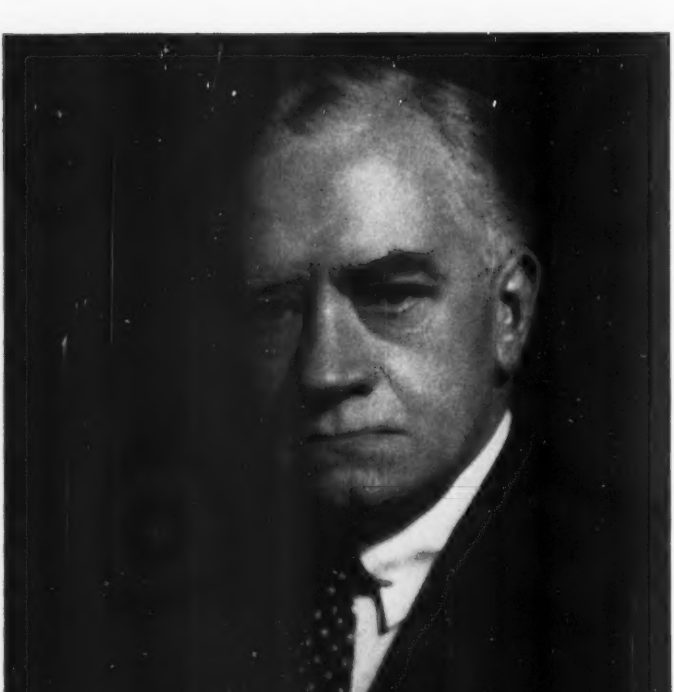
I met him first in 1932 when I was appointed to the Chair of Surgery in the University of Aberdeen, and I and mine have had twenty years of unbroken kindness from him and from his. As sometimes happens with the physically afflicted, he seems early in life to have

come to terms with his handicap: a process which involves a purification of the spirit that sets its mark upon a man. The outward sign of this was an indomitable courage which refused to accept any restriction upon his riding, the only form of physical exercise open to him, and one which he followed with an almost perverse insistence up to the last, an insistence which not infrequently alarmed his friends. As was his habit, he remained entirely if unostentatiously faithful to his horse Redwing, whom he counted as a friend; and it is good to know that a "next-best" home has been found for this remarkable animal, as his rider would have wished. The inward sign was the effortless way in which he immediately established affectionate relationships with most children, and working relationships with even the intractable. To be with him in a children's ward was always an education in the art of surgery. Before such patients were segregated, he would give me his advice upon orthopaedic problems most generously: and—like the man—it was always simple advice, and eminently practicable.

Mitchell's broad education, wide interests and long experience made him a wise counsellor. His opinions were always definite and expressed in the clearest of terms. If the matter were private, one had to be prepared, on occasion, for unpalatable advice; often enough further reflection showed him to be right. In public matters his complete disinterestedness made his opinions and advice most influential; and I believe that it played a substantial part in the rapid and frictionless establishment of the orthopaedic service in the north-east. He was a man who had a mind, and knew it: and he was careful that others knew his mind. But no thought of himself was allowed to influence his views, and he was most generous to his fellows. Only two things disturbed his generally benevolent outlook: sins of omission, and any suspicion of "wangling." Then there would appear the prophetic malar flushes and the ominous stare, and the culprit would be left in no doubt of Mitchell's opinion of him.

He was good enough to serve two terms as an examiner in Surgery in the University of Edinburgh, and an excellent examiner he was—simple, direct and eminently fair. The whole staff looked forward to his arrival; everyone (even, I understand, the "ploughed") enjoyed meeting him.

I believe that the future history of surgery in Scotland will emphasise the part played by Alexander Mitchell in its development. Much more importantly, the memory of this simple, kindly, upright, accomplished man will continue to influence his colleagues and his students throughout their lives, and the multitude of his friends. J. L.



Dr M. N. SMITH-PETERSEN

1886-1953

Dr M. N. Smith-Petersen died on June 16 at the age of sixty-seven after a short illness. This sad news only trickled through to this country ten days later, and the result has been a numb and void feeling in the hearts of British and English-speaking orthopaedic surgeons throughout the world.

Dr Smith-Petersen's name is known to every medical man and woman. He has left his mark by virtue of his skill and thought, with reference to hip joint surgery in particular, but throughout his professional career his strong personality, mixed with a great sense of humility and kindness, attracted his patients, pupils and colleagues very closely to him. Not only was he the "surgical master," but the friend and confidant of all who had the privilege to come into contact with him. Although he was somewhat shy and sensitive as an individual, his powers of concentration and real deep thinking made him a great leader and teacher in the art and science of orthopaedic surgery.

He was born at Grimstad in Norway, and went to the United States in 1903, attending Westside High School, Milwaukee, before commencing his University education at the Universities of Chicago (1906–7) and Wisconsin and finally at the Harvard Medical School.

He qualified B.S. (Wisconsin) in 1910 and M.D. (Harvard) in 1914, and was awarded an Honorary M.D. of Oslo in 1946. In Boston, in addition to being Instructor in Orthopaedic Surgery at Harvard Medical School (1930–35) and Clinical Professor of Orthopaedic Surgery (1935–46), he became Chief of the Orthopaedic Service at the Massachusetts General Hospital (1929–46). This Scandinavian-American mixture had the strongest anglophile leanings, and these were further developed by his contact with British orthopaedic surgeons, in particular Sir Robert Jones in the latter half of the first world war, and subsequently.

From very early days in his medical career Smith-Petersen was a pioneer. In the course of his Moynihan Lecture in 1947, he himself told the story of the original planning and execution of the anterior approach to the hip joint in 1917, stimulated in the first place by Dr Roy Abbott, and encouraged later by his Chief, Dr Elliott G. Brackett, with whom he worked in the greatest harmony for many years. Subsequently, this approach was developed into the acetabuloplasty operation, which he described in 1936 for the relief of pain and restoration of function in cases of malum coxae senilis, old slipped upper femoral epiphysis, intrapelvic protrusion of the acetabulum and coxa plana.

Three years later, we find a further development in the form of vitallium mould arthroplasty, with preliminary trials of several materials including glass (1923), viscoloid (1925), pyrex (1933) and bakelite (1938). There can be no doubt that the thought, study and care which Dr Smith-Petersen put into his work on arthroplasty of the hip provoked world-wide interest and progress, and it is to be noted that a long period of research preceded his final operative technique.

Of course, his fame in connection with the hip joint dates back to 1930–31, when he introduced the use of the three-flanged nail for internal fixation in femoral neck fractures. At that time, he wrote: "A great responsibility rests on the surgeon who introduces a new method of treatment. The desire to have a new idea published is so great that the originator is often led astray, and the method is broadcast before it has proved worthwhile, and before the technique has been perfected." This humble approach to his work was typical of the man, but there is no doubt that the opposition he aroused as a pioneer made him somewhat hypersensitive to criticism, and this was most apparent in his work on the surgery of sacro-iliac disease. His great aim, both in theory and practice, was to be constructive, and thus we find him developing many procedures for the relief of pain and restoration of function in the deformed joints of the unfortunate sufferers from chronic arthritis. One of the more dramatic of these operations is spinal osteotomy, for correction of severe fixed flexion deformity, and in 1941 the whole conception of this procedure was worked out on paper to the last detail, before being put into effect most successfully and dramatically.

As an operator, he was slow and meticulous. In this respect he was much influenced by his early training under Harvey Cushing, when doing an internship at the Peter Bent Brigham Hospital (1914–15), and the exposure and closure of all his operations followed the normal anatomical pattern as closely as possible.

Dr Smith-Petersen undoubtedly was seen at his best when dealing with patients, either on a ward round or in his office. Every problem was an individual one, and with his quiet smile and sly wink he captivated both patients and pupils alike. No man has ever portrayed the essential spirit of the doctor-patient relationship better. On social occasions, he loved to be surrounded by the younger men who were his students and pupils, "toasting" in a Scandinavian manner, and provoking both thoughtful and humorous discussion, but always reaching and clarifying the fundamental issues at stake.

After the second world war he visited Great Britain in 1947, 1948 and 1952. On the foremost occasion he was made an Honorary Fellow of the British Orthopaedic Association, and also delivered the fourth Moynihan Lecture at the University of Leeds. He also took charge of the orthopaedic staff conference and operated before a distinguished audience at the London Hospital. At a reception following this occasion the gift of his characteristic

ties will long be remembered by the recipients. It was during this friendly and amusing ceremony that the household dog laid her favourite bone at Dr Smith-Petersen's feet, and this bone was none other than half the pelvis including the hip joint! After the termination of this visit to England a Jensen silver bowl was presented to him by the staff of the London Hospital at a simple and moving little ceremony, which brought tears to the eyes of this great and sentimental man.

A year ago Dr Smith-Petersen, accompanied by his wife, visited London to be given the Honorary Fellowship of the Royal Society of Medicine, and to attend the meeting of English-speaking orthopaedic surgeons in London and the provinces. Fortunately, he had a chance of seeing most of his friends and was able to visit several of their homes, so our memory of him is both recent and happy.

These visits to Great Britain were always followed by a return to his native land, Norway, where he was held in high esteem. In 1946 he was honoured with the award of Commander of the Royal Norwegian Order of Saint Olaf, and received the Grand Cross in 1947. He was also an Honorary Member of the Norwegian Surgical Association.

Other societies which awarded him honorary membership include the Canadian Orthopaedic Association, the Royal Medical Society of Edinburgh and the Italian Society of Orthopaedic Surgery and Traumatology. He was a Fellow of the American Orthopaedic Association, and held the office of president of the American Academy of Orthopaedic Surgery in 1943. During the second world war he was consultant in orthopaedic surgery to the Surgeon General. He was also a member of the International Society of Orthopaedic Surgeons, and an Associate Member of the French Academy of Orthopaedic Surgery.

To Mrs Smith-Petersen, whom he married in 1917 and who hailed from Fitchburg, to his daughter Hilda, and to his two sons Porter and Morten, we extend our deepest sympathy in their bereavement, and we wish them to know that orthopaedic surgeons the world over are sharing their great loss, and will miss the stimulus of this great orthopaedic surgeon and thinker.

W. A. L.

PROCEEDINGS AND REPORTS OF UNIVERSITIES, COLLEGES, COUNCILS AND ASSOCIATIONS

GREAT BRITAIN

BRITISH ORTHOPAEDIC ASSOCIATION

SPRING MEETING

The spring meeting of the British Orthopaedic Association was held in Dublin from April 23–25 under the presidency of Sir Reginald Watson-Jones. This is the first time that the British Orthopaedic Association has met in Eire and although the festival of flowers and flags and street-decorations in Dublin may not have been planned especially for us, the warmth of welcome at this time when Eire was "at home" not only by the president of the Royal College of Surgeons in

The very first Edward Hallaran Bennett Medal, struck in 1906, which was presented by Dr Doolin to the President of the British Orthopaedic Association.

Ireland, the professors of the medical schools, and the Master of Trinity, but by every policeman, hotel attendant and man and woman in the street, was so generous that we all felt happy and came away with a warm sense of satisfaction.

The Executive Committee met at 7 p.m. on the eve of the meeting and did not finish its work until nearly 5 o'clock the next morning—many members being so tired before they began that they were utterly exhausted when they had finished. But steps have now been taken to prevent repetition of such marathon activity which is unfair to the president and unhelpful to the members of the Executive.

During the meeting a message from Her Majesty the Queen was read, expressing appreciation of the birthday greetings which had been sent by the president on behalf of the fellows and members of the Association.

At the dinner the toast of the British Orthopaedic Association was proposed by Dr J. Ryan, Minister of Health in Eire. The vigorous and forthright response from Dr William Doolin disturbed many of us who were not fully aware of the Irish temperament—but apparently all was well and all still is well. Dr Doolin gave to the president the first original medal struck in honour of Edward Hallaran Bennett—the first of the awards now given each year to the most distinguished student in surgery. This first copy of the Hallaran Bennett Medal will be preserved with the treasures and archives of the British Orthopaedic Association which are now being collected and will be displayed in the Exhibition Hall of the newly rebuilt Royal College of Surgeons of England.

Transfusion of blood, plasma and plasma substitutes—*Dr W. E. R. Hackett* (Dublin) discussed the advantages of transfusions of blood, plasma and plasma substitutes before and during surgical operations. In anaemic patients who required transfusion before operation it was important that the blood be given several days beforehand so that the body might be enabled to benefit as fully as possible. Blood given during operation had its greatest usefulness in replacing blood lost. This was often greater than was realised. An often unsuspected source of blood loss

was bleeding into the tissues, and this was an important cause of oligaemic shock after injuries such as fractures and extensive limb wounds. The risks of overloading the circulation by over-transfusion were small; a commoner error was not to give enough blood. With expert laboratory facilities reactions from mis-matching were exceptional; mistakes, when they occurred, were more often due to clerical errors or confusion of patients with similar names rather than to mistakes in grouping. In practice the only Rhesus factor of real importance was the D-antigen.

So far there was no true substitute for blood. So-called blood substitutes were really plasma substitutes, and none was equal to plasma itself. A perfect plasma substitute must have the same osmotic properties as plasma; this was very difficult to achieve in practice. The best types at present available were the polyvynyl polymers such as "plasmasan" and the sugar polymers such as "dextran."

The close-packed position of joints and its practical bearing—*Professor M. A. MacConaill* (Cork) defined the close-packed position of a joint as one in which the surfaces were completely congruent and the ligaments taut: it was a position in which the component bones of the joint were inseparable by traction. There was only one such position for most joints (there were two for the elbow, which was essentially a combination of two joints). For example, in the shoulder joint the close-packed position was one of abduction and lateral rotation; and for the hip it was one of slight abduction, extension and slight medial rotation; for the fingers, the close-packed position was extension, and for the metacarpo-phalangeal joints, flexion. The close-packed position imparted the greatest stability and rigidity to the joint, but it was used only during special effort.

Ocular torticollis—*Professor L. E. Werner* (Dublin) recalled the significance of imbalance of the ocular muscles as a cause of tilting of the head in infants and young children. When due to an ocular imbalance such tilting could be corrected by an equalising operation upon the eye muscles, though in long-standing cases secondary contractures of the neck muscles might occur. Professor Werner assessed cases of torticollis as being 1) purely ocular, 2) purely cervical, or 3) combined. From the orthopaedic point of view it was necessary to determine as soon as possible in every case of torticollis whether or not there was an ocular element in the deformity, if necessary by referring the patient to an orthoptic clinic. If an ocular defect was overlooked orthopaedic treatment directed to the neck would be incompletely successful.

Fracture of the head of the radius treated by excision and substitution of an acrylic head—*Mr J. C. Cherry* (Dublin) had replaced the fractured radial head by an acrylic prosthesis in selected cases in which the head was badly comminuted. He described and illustrated the prostheses and the special instruments used for their insertion, and gave details of the operative technique. A full account of the method was published by Mr Cherry in the February 1953 number of the Journal (Vol. **35 B,** page 70). *Mr C. C. Jeffery* (Exeter) believed that the operation had a definite place, especially in cases of fracture in which the radial shaft was displaced upwards. Such fractures were, however, exceptional. He had examined radiographs of the wrists of a large series of patients who had submitted to excision of the head of the radius, and in none was he able to find evidence of radio-ulnar subluxation. If replacement by an acrylic prosthesis could be shown to limit new bone formation it might have a place even when the radial shaft was undisplaced. *Professor Bryan McFarland* (Liverpool) had found no tendency for the radial shaft to migrate upwards, even when the radial head had been excised in children. *Mr F. G. St C. Strange* (Canterbury) recalled that the position of the radius depended upon the integrity of the interosseous membrane. If this was torn by the force of the injury the radius was displaced but if the membrane remained intact displacement was not to be feared. *Mr Philip Wiles* (London) thought that it was necessary to know the late results of prosthetic replacement before the place of the operation could be determined. *Mr Arthur Chance* (Dublin) believed that the radius might move upwards when weight was put on the wrist (e.g., leaning on a table) even though it appeared in normal position in routine radiographs. There was an established place for the operation, but if the capitulum was found to be badly damaged at operation acrylic replacement was better avoided. *Sir Reginald Watson-Jones* (London) had no doubt that the operation was appropriate for the rare but definite cases in which fracture of the radial head was associated with rupture of the interosseous membrane and marked upward displacement of the radius. *Mr Cherry*, closing, emphasised that he preferred to reserve acrylic replacement for exceptional fractures; he still relied, in most cases, upon conservative treatment.

Treatment of club foot—*Mr A. T. Fripp* (London) discussed the treatment of relapsed or neglected congenital club foot in children of from six months to ten years of age. For the past four years he had given an extensive trial to the Kite technique in which wedged plasters are used and he had been impressed by the results. The technique aimed at gradual correction without harmful force and without anaesthesia. Each of the four components of the deformity (varus,

inversion, equinus and plantaris) was corrected successively by removing appropriate wedges from the plaster and closing the gap, the adjustments being made at weekly intervals. The average duration of plaster treatment was twenty-one weeks. Mr Fripp had found that during treatment the foot became progressively more supple and that in nearly all cases satisfactory correction was obtained. In his series the period of plaster treatment had been followed routinely by transfer of the tibialis anterior tendon towards the lateral border of the foot; occasionally it had been supplemented by a soft-tissue operation of the Brockman type. Associated congenital anomalies and stiffness from previous unsuccessful bone operations might offer insuperable difficulties to correction. *Professor Bryan McFarland* (Liverpool) agreed whole-heartedly with the principle of gradual correction without the use of force. He thought there might be advantages in repeated plasters rather than wedged plasters. He emphasised the importance of correcting the individual components of the deformity one by one. Such a method reduced the necessity for operation, though it did not eliminate it. *Mr K. I. Nissen* (London) doubted the wisdom of transposing the tibialis anterior tendon to the lateral side of the foot as a routine; over-correction might result.

Pott's paraplegia and its operative treatment—Opening a discussion jointly with Mr D. Lloyd Griffiths and Mr R. Roaf, *Mr H. J. Seddon* (London) spoke mainly of pathology, prognosis and indications for operation. He recalled that much of our knowledge of the pathology of Pott's disease was owed to French workers at Berck, and especially to Madame Sorrel Dejerine. In paraplegia of early onset the cord might be involved by an inflammatory lesion (fluid or solid), rarely by thrombosis of the vessels, and sometimes by mechanical collapse of the spine. When paraplegia arose towards the end of a period of conservative treatment it almost merited the term "intermediate paraplegia"; its pathology was the same as that of early onset paraplegia except that it was never due to a fluid abscess. Paraplegia of late onset was associated either with an inflammatory process or with pronounced bony deformity. The cord changes in paraplegia were of four kinds: simple compression, infective thrombosis, pachymeningitis (rare) and longitudinal shrinkage. With conservative treatment alone paraplegia of early onset persisted in about one quarter of all cases and paraplegia of late onset in over half the cases. Operative treatment offered a good prospect of mechanical relief: fluid pus could be drained by costo-transversectomy, but solid matter interfering with the cord was best removed by antero-lateral decompression (except in the neck and in certain lumbar lesions, where laminectomy offered advantages). Operation was indicated 1) when paralysis had become complete; 2) in all late onset cases; 3) if continued improvement was not occurring under conservative treatment; 4) when paraplegia was associated with uncontrollable spasms of the legs; and 5) if paraplegia recurred after initial recovery. Operation should be considered relatively early in older patients. In cases with visible abscess shadow costo-transversectomy should be tried first but if it was unsuccessful antero-lateral decompression should be undertaken.

Mr D. Lloyd Griffiths (Manchester) described in detail the operation of antero-lateral decompression as employed by Mr Seddon, Mr Roaf and himself. He emphasised that operation was by no means required in every case. It was a difficult, formidable and hazardous operation and patients should not be submitted to it unnecessarily. A wide exposure, with removal of the medial ends of three or four ribs, was recommended. The spinal theca was exposed by removal of one or more pedicles and any source of pressure lying anteriorly in the region of the vertebral body was removed. After antero-lateral decompression stability of the spinal column depended almost entirely on the posterior structures. Mr Griffiths summarised the combined results in forty-eight patients operated upon by Mr Seddon, Mr Roaf and himself. Thirty-four recovered sufficiently to walk normally; eleven patients made little or no recovery, and three patients died. In successful cases recovery was often dramatic. Results were better in early cases with active disease than in late cases with marked bony deformity. Spinal fusion was always advisable after antero-lateral decompression. *Mr F. W. Holdsworth* (Sheffield) said that with the introduction of antero-lateral decompression our ideas on the treatment of Pott's paraplegia had been revolutionised. Operation seemed strongly indicated in any case in which recovery was not occurring with conservative treatment. Antibiotics had helped to make operation safer. *Mr Norman Capener* (Exeter) stressed that operation should not be undertaken lightly. The operation he had described was essentially the same as that recommended by Mr Griffiths, but he thought it unnecessary to remove more than one or two ribs. He was interested in Wilkinson's suggestion that the usefulness of operations of this type might be extended to cases in which there was no paraplegia. *Mr J. Dobson* (Wrightington) agreed that antero-lateral decompression represented a great advance. It should be done only in specially equipped centres. He emphasised the importance of treating the tuberculous patient as a whole by constitutional measures. *Mr R. W. Butler* (Cambridge) believed that antero-lateral decompression would greatly shorten the duration of paraplegia and would permit recovery in many patients who would not otherwise recover.

The orthopaedic treatment of early poliomyelitis—*Sir Harry Platt* (Manchester) opened a discussion with some general observations on the problems of poliomyelitis. He recalled the characteristic features of outbreaks of poliomyelitis of a generation ago. Such outbreaks were always small and children were almost exclusively affected. The main problem was that of preventing and relieving crippling deformity. As a result of the greatly increased incidence of poliomyelitis and the frequent affection of adults the subject had assumed an even greater importance in recent years. The prevention of deformity was still one of the main problems. This could be tackled efficiently by the orthopaedic surgeon only if the patient came under his care at an early stage. There was unfortunately a tendency for patients to be brought too late to the orthopaedic surgeon. *Mr D. M. Brooks* (London) outlined a programme of treatment for patients with poliomyelitis. He recalled that the aims of treatment were to save life, to prevent deformity, to restore function and to rehabilitate the patient. The orthopaedic surgeon should have access to the patient at an early stage and he should have a full knowledge of the complications that endangered life and of their management, including the use of different types of respirator. In preventing deformity the surgeon must remember its two causes—faulty posture and muscle imbalance. Faulty posture, which might sometimes be assumed in an attempt to minimise pain, was always preventable by appropriate splints and early passive movements: drop foot and back knee were common examples. Deformity from muscle imbalance—essentially a phenomenon of childhood—was more difficult to control. Experience showed that if muscle imbalance was marked it was impossible to prevent the occurrence of deformity simply by external retentive apparatus. Relatively early tendon transplantation was often necessary.

In planning the programme of treatment designed to restore the greatest possible function Mr Brooks advocated a commonsense approach. Active use of recovering muscles should be begun with caution at first and increased gradually. It was wrong to "flog" the muscles from the beginning of treatment with the idea that hypertrophy of muscle fibres would necessarily be induced by fatigue. Fatigue could be harmful, especially within the first three months. Electrical muscle tests were of value in determining at an early stage whether paralysis was doomed to be permanent. In general, it was true that if a muscle showed no sign of recovery within three months it was unlikely ever to recover. In such circumstances any necessary tendon transplantations could be proceeded with without delay. *Mr H. H. Langston* (Winchester) said that it was important that the orthopaedic surgeon should have early access to patients with poliomyelitis. There was a tendency for too much delay. *Professor Bryan McFarland* (Liverpool) believed that early orthopaedic management would best be secured by the efforts of individual orthopaedic surgeons each in his own area. *Mr R. I. Stirling* (Edinburgh) suggested that in times of epidemics blocks of beds in fever hospitals should be put at the disposal of the orthopaedic surgeons, who otherwise might be unable to accommodate the large numbers of cases in their own wards. *Mr J. C. Scott* (Oxford) believed that in the early stages the ideal arrangement was a close co-operation between orthopaedic surgeons, paediatricians and fever physicians. Orthopaedic surgeons should strive to contribute more to the solution of problems of the early phases of the disease.

Dupuytren's contracture—*Mr J. I. P. James* (London) reviewed some of the features of Dupuytren's contracture. He described in detail the anatomy of the palmar fascia and especially of its digital extensions. He recognised contracture of the fifth finger as a distinct clinical type in which the distal interphalangeal was not uncommonly involved. He had found "knuckle pads" associated with Dupuytren's contracture in nearly a quarter of all his cases; the histology of the pads was similar to that of the palmar fascia. Plantar involvement was also frequent. Subcutaneous tenotomy was occasionally justified in the elderly, but in the ordinary case excision of the palmar fascia, through a skin-crease palmar incision and through mid-lateral digital incisions, was recommended. The greatest hazard was oedema of the hand which might lead to a type of "frozen hand" possibly analogous to Sudeck's atrophy. This was the commonest cause of failure. Of eighty-four cases reviewed the result was perfect or good in sixty-four, and fair or poor in twenty. Metacarpo-phalangeal contractures could usually be overcome whereas interphalangeal contractures were very liable to persist.

Metatarsalgia—*Mr D. F. Thomas* (Scunthorpe) recalled that metatarsalgia was nothing more than a symptom. Often there was no precise cause and the site of the pain was ill-localised. Mr Thomas believed that in many such cases the underlying disorder was a weakness or insufficiency of the tibialis anterior, which allowed drooping of the forefoot. Treatment was by physiotherapy, but if this was unsuccessful transplant of the toe extensors into the metatarsal heads should be considered.

The place of amputation of all toes—*Mr K. I. Nissen* (London) said that there was a definite place for amputation of all the toes. The operation seemed to have become rather neglected. It was most applicable to cases of gross deformity with rigid, functionless but painful toes. Such

conditions most commonly followed "burnt out" rheumatoid arthritis; occasionally they were induced by peroneal muscular atrophy or by frost-bite. The nature of the proposed operation should always be clearly impressed upon the patient, whose written permission should be secured. After operation it was often possible for ordinary shoes to be worn, but sometimes special shoes were required. There might be a tendency to persistent trouble from pressure over the metatarsal heads, and irritative cysts might require excision.

Tendon transplants for claw toes—*Mr R. G. Taylor* (Oxford) had studied the results, in sixty-eight patients, of Girdlestone's operation of transplantation of the long toe flexors into the extensor expansion for claw toes. This paper was published in full in the 1951 number of the Journal (**33 B,** 539).

Colles fracture—*Mr W. Doolin* (Dublin), opening a discussion on Colles fracture of the wrist, sketched the scientific, cultural and social background against which Abraham Colles occupied with such distinction the Chair of Surgery in Dublin. Though he was undoubtedly the leader of his profession in his lifetime he was nevertheless a man of exceptional modesty. He was admired by his colleagues and students alike for his upright character and intense honesty. (This paper will be published in full in a future number of the Journal.) *Mr G. N. Golden* (Guildford) had studied the late results in 110 cases of Colles fracture treated one to twenty years before. Most fractures had been treated by junior residents and the usual method had been manipulative reduction and immobilisation in plaster for four weeks. Fifteen fractures had required remanipulation for secondary displacement. Results were assessed on the basis of pain, functional disability and deformity. Mr Golden concluded that age alone was not an important factor in the result. The type of fracture was of some significance, the incidence of poor results being greater after comminuted fractures and especially after fractures complicated by radio-ulnar subluxation. There was a definite and striking relationship between the quality of the reduction maintained and the results. It was suggested that more stable reduction and consequently improved results might follow the use of above-elbow plasters. *Dr W. R. Harris* (Toronto) said that one of the difficulties was to maintain reduction. He and his colleagues in Toronto believed that the use of plaster-of-paris was an inefficient method, especially in comminuted fractures. In selected patients a trial had been given to mechanical fixation by pin units of the Roger Anderson type, the pins being passed into the radius above the fracture and into the shaft of the second metacarpal distally, and retained for six weeks. Tension on the skin around the pins was avoided by reducing the fracture before the pins were inserted. In twenty-three cases observed for from two months to five years after treatment there had been no recurrence of deformity and no patient had lost more than 5 degrees of wrist movement. In two cases the pin fixation had to be abandoned because of pin-track infection.

Median nerve compression in the carpal tunnel—*Mr J. S. R. Golding* (London) recalled that pain and tingling in the distribution of the median nerve in the hand were commonly due to compression of the median nerve behind the flexor retinaculum. He had studied the clinical features and results in fifty patients subjected to operation. Most patients were women in middle life and the symptoms were bilateral in half. Tingling at night was prominent and was often relieved by hanging the arm out of bed or shaking it. There was usually impairment of sensation and sometimes there were motor weakness and wasting, which might be confined to the abductor pollicis brevis and opponens pollicis. The causes of the narrowing of the tunnel fell into two groups—non-traumatic and traumatic. Non-traumatic conditions included ganglion, tenosynovitis, changes in the flexor retinaculum itself (acromegaly, Léri's pleonosteosis) and idiopathic. The traumatic group included early lesions such as haematoma, carpal dislocation and fractures with displaced fragments, and late lesions such as old fractured scaphoid and gross traumatic arthritis. The results of decompression by division of the flexor retinaculum were good. The symptoms were almost always relieved. There was usually good or moderate recovery of sensibility, but motor impairment often persisted. *Mr F. C. Durbin* (Exeter) thought that the nocturnal paraesthesiae might be aggravated by a tendency to lie with the wrist flexed. He believed that night-splints to hold the wrist in a neutral position might reduce nocturnal discomfort and might sometimes obviate the need for operation. *Sir Reginald Watson-Jones* (London) recalled that in certain cases of median compression by haematoma after direct injury to the palm operative decompression might be required urgently.

Edward Hallaran Bennett—*Mr W. Gissane* (Birmingham) paid a tribute to the memory of Edward Hallaran Bennett (1837–1907) who was at one time Professor of Surgery in Dublin and who described the injury now widely known as Bennett's fracture. The original specimens on which Bennett had based his accurate description were demonstrated. Mr Gissane said that the injury was now believed to be an adduction injury, and stressed that although it might be reduced clinically without difficulty (as had been claimed by Bennett before the days of x-rays) it was difficult yet

essential to obtain and maintain close radiographic reduction. Operative suture of the ruptured joint capsule might be required to prevent redisplacement and, when necessary, this should be done early while the damaged tissues were still recognisable and easily handled. For late disability after inadequate reduction arthrodesis was preferable to arthroplasty.

Posterior ischio-femoral arthrodesis by a femoral graft—*Mr N. S. Martin* (Belfast) traced the evolution of ischio-femoral arthrodesis of the hip from its first description by Trumble in 1932. He recalled that Brittain's technique (1942) had itself been modified by Foley (1949) who recommended an open approach with the patient prone. Mr Martin had been impressed by the disadvantages of taking a large graft from the tibia and had developed a technique of open posterior fusion in which a femoral graft was obtained through the same incision. He showed radiographs to prove that the technique had been uniformly successful in over thirty cases.

Clinical meeting—A clinical meeting was held at Dr Steevens's Hospital, Dublin. A large number of interesting and instructive patients had been brought together from many parts of Ireland and were demonstrated by Mr A. Chance (Dublin), Mr H. F. McAuley (Dublin), Mr J. E. C. Cherry (Dublin), Mr P. A. M. Fitzgerald (Dublin), Mr St J. G. O'Connell (Cork), Mr R. F. O'Driscoll (Waterford) and Mr J. F. O'Sullivan (Dublin).

ROBERT JONES GOLF CUP

The annual competition for the Robert Jones Golf Cup was played on the links of the Portmarnock Golf Club near Dublin during the Spring Meeting of 1953. The Portmarnock Golf Course is beautifully situated on the edge of the sea, just north of Dublin, and we were fortunate in being blessed by warm, sunny weather.

The Cup was won for the second time by Mr G. K. McKee of Norwich who returned the excellent score of 88—15—73. He won by three strokes from Mr N. Roberts, Mr Maitland Smith and Mr J. Quinlan, who returned net scores of 76. Eighteen competitors took part in the competition—a very satisfactory entry as the total number of members attending the Dublin Meeting was considerably smaller than usual. The captain of the Portmarnock Golf Club visited the course to meet us and we were all made extremely welcome, both by him and the other members of the club.

ROYAL SOCIETY OF MEDICINE

A meeting of the Orthopaedic Section of the Royal Society of Medicine was held at the Heritage Craft Schools and Hospitals, Chailey, on May 9, 1953, under the presidency of Mr H. Jackson Burrows. About 120 members and guests were present. The morning session was devoted to short papers read by members of the hospital staff.

Infantile hemiplegia—A symposium was presented. *Dr E. P. Quibell* gave a preliminary report into the incidence of chronic subdural haematoma in infantile hemiplegia in a group of school-age children at the Heritage Craft Schools and Hospitals. So far, four proven cases with large lesions had been found, in boys between eleven and sixteen years old: all had had fits, usually in early life, with a history of difficult birth. Plain radiography was valuable in showing thinning and bulging of the skull overlying the lesion. The haematomata had all been left-sided. The investigation was continuing, to establish diagnostic criteria, the age at which the radiological changes appear and to study the effects of drainage of the lesions on the intelligence.

Mr E. J. Radley Smith emphasised that this was purely a preliminary investigation. He said that the paralysis was most often left-sided and widespread, but in spite of this intelligence was little affected and there was no speech defect. There was a bulge on the fronto-parietal region of the affected side. The cerebro-spinal fluid was normal. Ventriculography showed a deviation of the ventricular system towards the side of the haematoma. Operation for drainage had produced subjective improvement in these late cases. He did not know the reason for this.

Dr A. M. Rackow spoke of the radiographic appearances. He said that the points to be noted were: 1) calcification of the haematoma; 2) flattening of the skull; 3) evidence of pressure on the great and lesser wings of the sphenoid; 4) forward bulge of the anterior wall of the middle fossa.

Dr Aldren Turner suggested that angiograms might be a better method of study than air ventriculography. He wondered whether operation was justified in late cases as the damage to the brain had already occurred.

Phocomelia—*Mr W. D. Coltart* read a paper on phocomelia. This proved to be a classification of congenital defects of the lower limb under three headings: 1) proximal femoral dysostosis; 2) congenital short femur; 3) cervical dysplasia. A case was described and radiographs shown.

Management of the bladder in paraplegic children—*Mr Ellison Nash* spoke on the treatment of the bladder in paraplegic children. He stressed the importance of residual urine and stated that if more than one ounce was present the child needed two-hourly manual expression. Bladder neck resection was sometimes necessary, also the removal of diverticula which might necessitate

ureteric transplantation. Complete incontinence was treated by plication of the urethra. He mentioned the value of methyl ephedrine and advocated permanent suprapubic drainage if other methods failed.

Correction of deformities by splinting—*Dr E. E. Harris* showed ten children illustrating the effect of prolonged splinting in plaster, resulting in clinical loss of spasticity. This effect could be maintained in many cases by suitable night splinting only, and could therefore in them be long-term treatment as well as a factor in assessing operative results.

Contribution of paediatrics to orthopaedic surgery—*Dr C. P. Pinckney* spoke on the contribution of paediatrics to orthopaedic surgery. He discussed measures for the protection of the mother against virus infections during early pregnancy, and for the prevention of nutritional disorders. The need for vitamin D in the diet of city children was emphasised and the types of rickets classified. The management of rheumatoid arthritis and tuberculosis was in conjunction with the paediatrician.

Members and guests were invited by the Hospital Management to lunch, at which Mr S. L. Higgs told the story of the Heritage and of its founder Mrs Kimmins. The afternoon was devoted to a tour of the hospitals and workshops.

REGIONAL ORTHOPAEDIC CLUBS

SOUTH-EAST METROPOLITAN REGION ORTHOPAEDIC CLUB

Two meetings of the South-East Metropolitan Region Orthopaedic Club have been held during the winter.

Films—The meeting on November 29, 1952, at King's College Hospital was devoted to a series of films of orthopaedic interest. About forty members and guests were present. The following films were shown: 1) Mould arthroplasty of the hip—Mr W. A. Law; 2) Spinal bone grafting by anterior route—Professor Merle d'Aubigné; 3) Conservative operations for paralytic deformities of infants' feet—Professor B. McFarland; 4) Treatment of injuries of the extensor and flexor tendons of the hand—Mr R. G. Pulvertaft.

Mr Law was present to introduce and discuss his film. Time did not allow the showing of two other films which had been requested, and it was decided to devote an occasional meeting in future to orthopaedic films. After the meeting we were entertained to lunch by kind invitation of the Governors of King's College Hospital.

Clinical meeting—A clinical meeting was held at the Miller General Hospital, Greenwich, on March 21, 1953. About forty members and guests saw a wide variety of cases demonstrated by Messrs J. E. Buck, R. H. Sewell, M. B. Cashman and Dr J. Gold.

Among the cases demonstrated by *Mr J. E. Buck* were the following.

" Frozen " shoulder—A severe case in a woman of forty-seven treated by manipulation under anaesthesia and an intra-articular injection of 100 milligrams of cortisone at the same time. A relatively short course of physiotherapy had then resulted in excellent restoration of painless movement. This treatment had been used while the joint was still in an irritable acute phase, which Mr Buck felt sure would have been aggravated by manipulation without cortisone. Mr Buck had treated several similar cases in this way, and he had been struck by the great improvement in symptoms and the relatively rapid recovery. In discussion, *Mr Le Vay* related that he had recently been treating " frozen " shoulders by manipulation in conjunction with intramuscular injections of cortisone for two weeks. He also had been impressed, using this routine, by the marked clinical improvement even in patients who were manipulated during the irritable phase of the disorder. It was generally agreed by those present that the use of cortisone in this condition appeared to be a considerable advance.

Judet arthroplasty—A man of forty treated by Judet arthroplasty after fracture of the femoral neck with avascular necrosis of the femoral head. This patient had a good range of movement but complained of pain. Discussion ranged widely around the possible causes of pain after Judet arthroplasty.

Spastic flat foot—Two patients with spastic flat foot in whom relief of symptoms had followed excision of the contents of the sinus tarsi. One was painless and the other had some residual discomfort, but in both cases the feet remained valgoid.

Genu valgum—Severe genu valgum in a boy of fifteen treated by epiphysial stapling of the femora. Complete correction had occurred within a few months of the operation and the staples had subsequently been removed. The use of epiphysial stapling for severe genu valgum in young children was discussed. *Mr J. I. P. James* suggested that this method should not be used before the age of about ten.

Rupture of extensor pollicis longus tendon—Bilateral rupture of the extensor pollicis longus tendon following Colles fractures. On one side Mr Buck had produced a good functional result by tendon transplantation. The second side had not yet been operated on. *Mr David Trevor* enlivened the discussion by an emphatic re-statement of his views on the superiority of end-to-end suture of the ruptured extensor pollicis longus tendon with a nylon suture bridging the gap. The length of incision needed to find the retracted proximal end of the tendon was regarded by some members as a disadvantage of this operation, but Mr Trevor exploded this view by pointing to the scar resulting from tendon transplantation in the case under discussion.

Compound fracture—Ununited compound fracture of tibia and fibula with infection. Sound union and healing of the infection had resulted from compression applied by pins and clamps after other methods had failed.

Mr R. H. Sewell presented a variety of cases which included the following.

Primary Judet arthroplasty—Sub-capital fracture of the femoral neck treated by immediate Judet arthroplasty. Many members favoured this treatment for high femoral neck fractures on the view that avascular necrosis commonly follows nailing in these cases, whereas early weight bearing can be resumed in safety after Judet arthroplasty, particularly if the operation consists simply of replacing the femoral head without separation of the rectus origin, or excision of joint capsule.

Deformities after poliomyelitis—Old poliomyelitis in a boy of eight with pathological dislocation of the left hip joint and pes cavus. Suggestions for treatment were invited but it was felt that the lack of useful muscle power in this limb would make it extremely difficult to improve his function by any operative measures.

Slipped epiphysis—Two cases of slipped upper femoral epiphysis, bilateral in one case. Excellent results had followed wedge resection of the femoral neck in the unilateral case and on the worse side in the bilateral case.

Other cases—*Dr Joan Gold* demonstrated a young woman with advanced rheumatoid arthritis. Earlier treatment elsewhere with cortisone had improved her greatly but the condition had retrogressed when treatment was discontinued and she had become completely bedridden. She then started further cortisone treatment with careful physiotherapy and joint manipulations. A remarkable improvement had been effected and after several months of this treatment she was just starting to walk. It was agreed that cortisone must be continued in these cases to maintain the improvement.

Mr B. Cashman demonstrated and discussed an interesting case of caisson disease of the left hip in a man of thirty-six whose work exposed him to increased area pressures and who had previously suffered minor attacks of the "bends."

SOUTH-WEST ORTHOPAEDIC CLUB

A very successful spring meeting of the South-West Orthopaedic Club took place in Paris from May 27 to June 1, 1953, when ten members visited the clinics of Professor Merle d'Aubigné, Professor Robert Judet and Dr Pierre Petit, who had kindly arranged a programme.

At L'hôpital Cochin a clinical conference, a ward round, an out-patient clinic and an operating session were attended.

Arthroplasty of the hip—Arthroplasty of the hip was discussed and many follow-up cases were seen. *Professor d'Aubigné* had carried out an investigation of hips operated on for insertion of an acrylic prosthesis during the last four years. He had noted that during the first two years a certain number with fair results improved in function, but after this time some with good results deteriorated—the proportions of each being approximately equal. He demonstrated a collection of eighteen prostheses which had fractured and which it had been necessary to remove. He was now inserting an acrylic prosthesis of his own design. Many problems of reconstructive surgery after fractures and trauma were seen.

Spinal fusion for spondylolisthesis—*Professor Merle d'Aubigné* also showed a film demonstrating his method of fusion of the lumbo-sacral junction in spondylolisthesis, using an anterior trans-abdominal route. The operation was carried out in collaboration with an abdominal surgeon. A graft from the iliac crest was inserted into the space between the fifth lumbar vertebral body and that of the first sacral after the disc had been curetted. The graft and vertebral bodies were then held in position with a long stainless steel screw. The method was only suitable for mild degrees of spondylolisthesis. Another film was shown of the treatment of Dupuytren's contracture.

Quadricepsplasty—A method of quadricepsplasty was demonstrated for overcoming the disability of the stiff knee after immobilisation. The quadriceps tendon was lengthened and the expansions were freed. This method improved the range of flexion, but resulted in about 20 degrees loss of extension.

Judet arthroplasty—At *Professor Robert Judet's* clinic at Square Desaix, the visitors attended an operating session, where an arthroplasty of hip for osteoarthritis was demonstrated. The usual

anterior incision favoured by Judet was used and an excellent view of the acetabulum was seen. This is obtained by the aid of an ingenious orthopaedic table, designed by Professor Judet, which allows extreme flexion of the hip, and thus permits the neck of the femur to be displaced posteriorly. Professor Judet was using a new type of prosthesis, as the type previously used by him was giving unsatisfactory long-term results. A lumbo-sacral fusion for spondylolisthesis, through a posterior route, and an operation for open reduction and grafting of a comminuted fracture of the calcaneum were also performed. In these cases stored bone was used, the bone being obtained from a full-term foetus foal under strictly aseptic conditions. The graft was stored in a " deep freeze " in penicillin and streptomycin solution.

Club foot—At the hospital of St Vincent de Paul, *Dr Pierre Petit* read a short paper on the treatment of club foot. He emphasised the importance of radiographs in the clinical examination to determine the extent of the bone deformity. He favoured conservative treatment with wedged plasters by the Kite method. In cases seen late, or after the failure of conservative methods, an operation for " medial release " was done. This consisted of lengthening the tibialis posterior and the tendo calcaneus and opening up the mid-tarsal and subtalar joints. At an operating session Dr Petit demonstrated clearly his " medial release " operation.

Congenital dislocation of the hip—*Dr Mealy* discussed the treatment of congenital dislocation of the hip by open operation, and its results, and showed a series of most interesting radiographs.

Scoliosis—*Dr Queneau* read a paper on the treatment of scoliosis. A rehabilitation unit for poliomyelitis at St Fargeau, outside Paris, was visited. This unit is sponsored by the Association des Paralysés de France.

The success of the meeting was in large part due to the great kindness and hospitality of the hosts to whom all the members are much indebted. A visit to the house where Delius died in a pretty little village in the forest of Fontainebleau was much appreciated. The language difficulty provided no problem because of the excellent English spoken by our lecturers and demonstrators and the more than adequate French spoken by Messrs Eyre-Brook and Bourdillon.

MANCHESTER REGION ORTHOPAEDIC CLUB

Demonstration of buoyant bathing suits—At a recent meeting of the Manchester Region Orthopaedic Club *Mr Ian D. Kitchin* (Lancaster) described the use of buoyant bathing suits, which have proved valuable in rehabilitation after poliomyelitis. A demonstration of the suits was given.

Mr Kitchin said that teaching the children to swim was at first an extremely slow process. Those rehabilitating after poliomyelitis required a great deal of assistance because of their disabilities, but many patients with poor posture and scoliosis presented even more difficult problems, for these conditions were frequently associated with marked timidity and lack of self-confidence.

The use of the buoyant swimming suits had greatly reduced the time necessary to teach the children to swim. They gained confidence quickly and could often be floating free and making some progress through the water before the end of one lesson. After a time they graduated to ordinary costumes.

The buoyant material of the swimming suits* was attached as a pad to the ventral surface of the costume, and was quite small (Fig. 1). It was not kapok. It was a woven material which was " water-repellent " and was so designed that, when it was immersed, air was trapped between the fibres of the material and remained imprisoned so long as the fabric remained wet—it never became sodden, never sank, and dried quickly after use. The additional buoyancy provided by the suit was just sufficient to keep the wearer floating comfortably, and, as the pad was attached in front, no matter how the patient entered the water or how helpless, he floated face upwards.

If the full suit was not required, small pads of

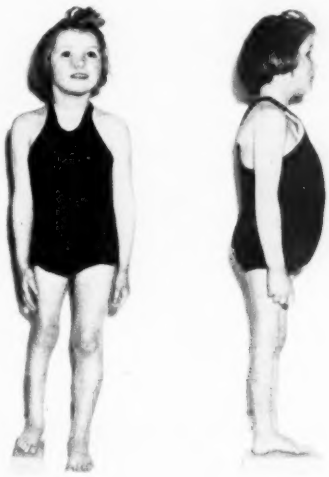


Fig. 1

Bathing suit with buoyancy material incorporated in the ventral surface.

* The suits are supplied by I. M. Dry (Rainwear) Ltd., Anchel Works, Upper Camp Street, Salford 7.

the material could be fastened to individual limbs in cases of poliomyelitis to keep them buoyant, and so maintain the child's balance and assist the disabled limb.

It had been found that the suits were very popular and that children taught to swim at the class would often attend the baths afterwards on their own; moreover they persevered with their swimming far more enthusiastically than with ordinary routine gymnasium exercises. A considerable gain in self-confidence was frequently observed.

The photographs (Fig. 1) give a good idea of the appearance of the suit. The pad, in this case, is rather larger than necessary for a child of this size.

LEEDS ORTHOPAEDIC CLUB

The first clinical meeting of the Leeds Orthopaedic Club was held at Bradford Royal Infirmary on March 20, 1953, under the chairmanship of Mr A. Naylor. A ward round was conducted by Mr A. Naylor and Mr J. Wishart. After tea clinical demonstrations were given.

Severed tendons in the hand—*Mr A. Naylor* showed a large series of miscellaneous tendon injuries in the hand treated by suture or tendon graft with excellent restoration of function.

Hallux valgus and rigidus—*Mr J. Wishart* demonstrated patients treated by arthrodesis of the first metatarso-phalangeal joint and all had complete relief of pain and an excellent gait. One patient so treated for metatarsus primus varus showed real improvement in the deformity since the operation.

Non-union of fracture-separation of lateral humeral condyle—This patient promoted lively discussion which centred round the advisability of performing anterior transposition of the ulnar nerve in anticipation of delayed ulnar paralysis and the consensus of opinion was that the operation ought to be deferred.

Osteoclastoma of femur—The lesion had presented in a condyle and clinically and radiographically appeared to be a tuberculous process. After excision the lesion proved histologically to be an osteoclastoma.

Chronic villonodular synovitis—*Mr Wishart* showed a case in which synovectomy of the affected knee had resulted in almost full function.

Poliomyelitis—*Mr Naylor* presented a series of tendon transplantations in the leg and foot in children and included hamstring transfers for quadriceps paralysis.

Lytic bone lesions in the skull—Radiographs of a well child showing punched-out areas in the skull were discussed. Biopsy had revealed only necrotic material and all present agreed that it should be repeated. Speculation on the diagnosis finally crystallised into a lipoid storage disease or metastases from a neuroblastoma.

BONE AND TOOTH SOCIETY

1953 MEETINGS

The Society held a meeting for Casual Communications at the Institute of Dental Surgery, The Eastman Dental Hospital, London, on January 21, 1953. Professor F. C. Wilkinson was in the chair.

Hydroxyproline in enamel keratin—*Dr M. V. Stack* described how four-fifths of the nitrogen in the acid-insoluble protein obtained in 0·18 per cent yield from pure enamel appeared in a soluble form after treatment with purified collagenase or with crystalline pepsin, trypsin or chymotrysin. Dentine collagen samples dissolved readily under the conditions chosen. The hydroxyproline content of such enzyme-treated enamel protein preparations was nevertheless 3 to 6 per cent, averaging three times less than that of collagen. Similar values were shown by protein samples submitted to prolonged treatment with cold mineral acids or with boiling water. Dentine collagen yields an insoluble protein containing only 0·3 to 0·6 per cent hydroxyproline under these conditions. This amino-acid is therefore likely to be a component of the insoluble protein of enamel. It is doubtful whether hydroxyproline has been detected before in a keratin. The present finding, in conjunction with others, indicates the need for a reconsideration of the classification of the acid-insoluble protein of enamel as an eukeratin.

Action of parathormone—*Dr C. E. Dent* described experiments carried out in conjunction with Drs A. D. Kenny and G. Philpot to test further the Albright-Ellsworth theory of the action of parathormone—namely, that the immediate result of an injection of parathormone is an increase in urinary phosphate output, followed by a fall in serum phosphate, and that this produces later on a slow rise in serum calcium levels. In twenty tests on fifteen subjects (mainly normal) they failed to find consistent increases in urinary phosphate. Plasma phosphate levels likewise showed no consistent changes except for some definite falls in four cases in all of which the phosphate was high to begin with. A chronic fall in plasma phosphate was brought about in three subjects by continued ingestion of aluminium hydroxide. No appreciable change in calcium levels took place. These results are taken to weaken the theory that the primary action of parathormone is on the kidney.

The parathyroid in relation to citrogenase activity and bone citrate—*Dr H. R. Perkins* had studied the citrate content and citrogenase activity of bone in parathyroidectomised and normal rats, and in normal rats injected with parathyroid extract. In animals examined five weeks after parathyroidectomy the bone citrogenase activity was much lower than in the other two groups, but their bone citrate content and alkaline phosphatase activity did not differ from normal. However, only four days after parathyroidectomy the bone citrogenase activity had not fallen below the normal value.

P exchange in new medullary bone of laying pullets—*Mr T. G. Taylor* described an experiment on which he had worked with Drs D. H. Tomlin and J. H. Moore. Six pullets on the point of lay were fed with P 32 continuously for periods varying from fourteen to twenty-seven days. Each bird was killed immediately after laying and the specific activity of the P in old (cortical) bone was found to vary between 6·7 and 15·7 per cent of the activity of the new (medullary) bone, which gives a measure of the extent to which P exchange had occurred. In other experiments the optical density of localised regions of autoradiographs prepared from bones of rats which had been fed on Ca 45 continuously for fourteen days were measured with microphotometer, which enabled a clear discrimination to be made between new and old bone. One-month-old rats showed 15 per cent exchange, six-month rats 8 per cent and nine-month rats 5 per cent.

Tartar-like deposits on animal teeth—*Mr S. L. Rowles* read a paper compiled by the late J. D. King, Dr K. Little, Dr J. Thewlis and himself on the significance of certain deposits on the teeth of experimental animals as causative factors in paradontal disease. Such deposits appeared to resemble closely salivary calculus (tartar) in man. Material was obtained from hamsters fed on high cereal and high sugar diets, and from ferrets fed on a diet of bread, meat and milk. The deposits were principally on the molar teeth of the hamster, and on the premolar and molar teeth of the ferret. Chemical analysis showed that the deposits found in both species contained a considerable proportion of calcium and orthophosphate in ratios like those found by Glock and Murray (1938) for human salivary calculus, and x-ray diffraction produced patterns closely resembling the hydroxyapatite patterns given by bone and dentine. (Glock, G. E., and Murray, M. M. 1938: Journal of Dental Research, **17**, 257.)

Metaphysial cellular changes in relation to growth rate—*Dr H. A. Sissons* gave an account of the experimental determination of rate of longitudinal bone growth. In rabbits and rats, the rate of growth of the epiphysial cartilage plate at the lower end of the femur had been measured radiologically. A figure of 0·31 millimetres per day was obtained for the rabbit (age nine weeks) and 0·18 per day for the rat (age fifty days). This information was used in interpreting the microscopic structure of the growing region of the bone in each species, and in determining the duration of each of the cellular processes concerned in the formation and maturation of bone trabeculae in this situation. The relative duration of the various cellular processes varied from species to species, and, in addition to variation in absolute growth rates, was responsible for the differences in the microscopic structure of the growing region in the two species studied.

The articular surface of joints—*Mr C. H. G. Price* showed slides which demonstrated the appearance of a fresh unfixed normal articular surface viewed by incident polarised light. Between the cartilage cells the matrix showed marked birefringence and appeared particulate rather than fibrous. The same surface in transverse section showed a markedly birefringent outer layer approximately 0·005 millimetres thick. This layer, and the subjacent tangential layer of the matrix were molecularly orientated parallel with the surface, with no clear evidence of fibres. It was further shown that on drying the cartilage, a fibre structure became visible at a magnification of × 100, to disappear again on replacement of the water. This difference was associated with the optical change from translucency to transparency, indicative of reduction of "pore size" of the matrix gel. The essential conclusion reached from this work was that surface tension at a gel/fluid interface is the basis for orientation of the surface layers of the gel—this process being aided by gravity and friction to form the articular surface. It was further suggested, from observations on cartilage and gelatine gels, that dehydration and chemical fixation might cause mutation of the collagen component of cartilage from a gel to fibre form. Since both of these processes are often preliminaries in preparing material for electron microscope and x-ray diffraction studies, collagen fibres demonstrated by these techniques should be accepted only with great reserve. These methods are eminently suited for producing a reversal of phase in cartilage matrix, thus leading from orientated gel to fibre structure.

Cutting machine for undecalcified hard tissues—*Dr G. C. Blake* demonstrated an adaptation of a commercial diamond-cutting instrument. A ¼ horse-power electric motor running at 2,850 r.p.m. drove a spindle at 10,000 r.p.m. by a special belt. The spindle ran between centres in replaceable fibre bushes, and carried a phosphor bronze disc 7 centimetres in diameter, 25 microns thick. The cutting edge of the disc was prepared with fine diamond powder. The material to be

sectioned was held in a rigid mount which was fed on to the disc by hydraulic pressure. Water was used as lubricant. Four sections per millimetre of hard tissue could be obtained; the sections were about 100 microns thick and their surfaces were smooth enough for immediate mounting. Examples of the sections demonstrated were of bones and teeth embedded both in paraffin wax and acrylic resin, some of which showed part-preservation of the soft tissues.

Innervation of the palate—*Dr F. W. Gairns* described and demonstrated how soft tissues of the buccal surface of the human palate have been prepared, sectioned and stained by a silver diammine ion method (Bielschowsky-Gros; see Garven and Gairns 1952). Many nerve endings of various types were present. The pattern of innervation resembled that of the gum, and included endings not found over the general skin surface. The dominant type of ending was a large "whorl" lying at different levels of the connective tissue papillae. From some of these "whorls" fine nerve fibrils could be seen to penetrate the epithelium and end in its outer layers.

Vitamin C and Bone: a Symposium

A symposium on "Vitamin C and Bone" was held at the Institute of Orthopaedics, Royal National Orthopaedic Hospital, London, at 5 p.m. on April 9, 1953, with Dr C. E. Dent in the Chair.

Radiography of scurvy—*Dr E. H. Allen* described and demonstrated the radiological changes in scorbutic bone, such as the broadened epiphysial line and rarefied shaft.

Vitamin C and ground substance—*Dr L. E. Glynn* described the study of the polysaccharides in normal human subcutaneous connective tissue after extraction and hydrolysis by electrophoresis and partition chromatography. Uronic acid was not found, and it must therefore be concluded that hyaluronic acid and chondroitin sulphate can be present only in trace amounts. The predominant hexose found after hydrolysis was galactose, with smaller amounts of mannose, glucosamine and glucose. Similar methods had been applied, combined with histochemical studies, in an investigation of granulation tissue, both in normal and scorbutic animals. Preliminary results confirmed the early work of Wohlbach that vitamin C was essential for collagen and reticulin formation, but were not in agreement with Penney and Balfour, who found that the vitamin was necessary for the production of intercellular (ground substance) polysaccharide. Some results on the non-collagen protein of connective tissue, presumably the ground substance protein, were also presented.

Vitamin C and ossification—*Dr G. H. Bourne* recalled that the effect of scurvy on healing of fractures had been known for about 200 years. That this delay was in fact due to vitamin C deficiency had been shown by experimental work of the last thirty years. Vitamin C deficiency exerted its effect in a number of ways: 1) it delayed the reaction of the osteogenetic membranes, endosteum and periosteum, to the injury; 2) it retarded the development of osteogenetic fibres; 3) it delayed the migration of polymorphs and macrophages to the injured area. The apparent reduction of phosphates in the injured area in the deficient animal was due to failure of development of phosphatase-impregnated fibres. Those fibres that did develop appeared to possess normal enzyme activity. In endochondral ossification vitamin C deficiency reduced the number of bony trabeculae formed in the cartilage. In costo-chondral junctions the pre-ossification alignment of cartilage cells was prevented and less phosphatase was present.

The relationship between cortisone and vitamin C—*Dr B. E. Clayton* discussed the role of the adrenal cortical hormones in bone formation, with special attention to the osteoporosis seen in Cushing's syndrome. ACTH or cortisone modified or inhibited epiphysial growth, and cortisone delayed the union of experimental fractures, depending on the doses employed and the species of animals used. Reports in the literature concerning the effect of cortisone on acute and chronic scurvy were very conflicting. Experience showed that it had not affected the final outcome of the disease. In acute or severe chronic scurvy, epiphysial structure was unchanged by cortisone therapy. In mild chronic scurvy, however, cortisone might favour the formation of new bone at the epiphysial line and subperiosteally. Experiments establishing these points were described and reference was made to relevant literature.

HOSPITAL FOR SICK CHILDREN, GREAT ORMOND STREET

SIMPSON SMITH LECTURE

Recent knowledge of affections of the skeleton in children—*Sir Thomas Fairbank*, consulting surgeon to the Hospital for Sick Children, then in its hundredth year, delivered on October 10, 1952, the annual Alex Simpson Smith Lecture, a memorial to a former junior colleague who fell in North Africa in the last war. The full lecture has been published, with illustrations and further references, in the *Great Ormond Street Journal*, December 1952. The lecturer confined attention to the rarer affections, only recently recognised and of unknown cause. In classifying the dysplasias the lecturer

thought it dangerous to do more than collect together those in which the same part of a bone (for instance, epiphysis or metaphysis) was the chief, though not necessarily the only, site of change. The mechanical origin of some congenital deformities had been strenuously and ingeniously supported by Denis Browne; Jansen had gone much further, but it was difficult to see how excessive intra-uterine pressure could account for cleido-cranial dysostosis, for instance. Sir Thomas referred to Duraiswami's notable work on environmentally induced foetal deformities, with evidence that they could be transmitted.

Thoraco-lumbar angular kyphosis, as in chondro-osteo-dystrophy, might well come from "spacial impairment" (Gordon 1950), being a variant or exaggeration of a normal foetal state (Kemp 1950). Here, a small, slightly displaced vertebral body might be seen in several conditions (Kemp 1946), for instance achondroplasia, neurofibromatosis and cretinism, and even in otherwise normal children; Dr Blair had shown him a small typically shaped body without kyphosis. He had found that its shape was always like that in gargoylism. In one case of the Morquio-Brailsford affection T.11, T.12 and L.2 were all affected (Fawcitt 1952). Sir Thomas knew three cases of complete absence of a vertebral body at the thoraco-lumbar junction without other skeletal errors, and in one of these two were deficient.

He believed that vertebra plana (Calvé 1925) would prove eventually to be one manifestation of lipoidosis, but unfortunately the whole skeleton was not radiographed in every case. This view was suggested by a case of xanthomatosis in the Great Ormond Street Hospital under Mr Eric Lloyd with osteolytic lesions in the skull, the ilia, the neck of one femur and the lower end of the other besides the characteristic changes in the ninth thoracic vertebral body; biopsy of one iliac crest revealed cholesterol deposits, the case being regarded as intermediate between eosinophilic granuloma and Hand-Schüller-Christian disease (Davies 1949). The vertebral changes had been seen in a rather similar case without biopsy (Little 1948), in a case of Gaucher's disease under Mr Buxton, in a case of multiple eosinophilic granuloma illustrated by Snapper (1949), and in a probable case of xanthomatosis, without biopsy, under Sir Harry Platt, with other bony lesions in the right ilium and femur and one humerus, all of which had cleared up eleven years afterwards though there was now considerable collapse of another vertebral body (Fawcitt).

Of conditions recently described, two presented the chief changes in the shafts, namely infantile cortical hyperostosis and Engelmann's disease. In the former the changes were mainly periosteal, in the second cortical. Infantile cortical hyperostosis had been described and named by Caffey and Silverman (1945), but two cases had been published in 1939, one by Caffey and the other by R. W. B. Ellis. Of about sixty cases now published, only eight had appeared in British journals, though Sir Thomas had seen three others unpublished. It was twice as common in boys as in girls, and the average age was about two and a half months if four possible cases at eighteen months and more were excluded. In eight cases signs appeared within the first month of life, and, in one, were present at birth (Kitchin 1951). Facial swelling, though stressed, was less often noticed than swelling or pains in a limb. Irritability, fretfulness and local tenderness were common; fever occurred sometime in at least half the cases; pseudoparalysis and respiratory troubles were other early indications. Usually several bones were affected, most commonly the ulna, humerus, tibia, mandible and radius in that order, often asymmetrically. Swelling involved the clavicle in twenty-three cases, the calvaria in two, facial bones in two, ribs in eighteen, the pelvis in three; the vertebrae escaped. The skin over affected bones was never red or hot. Soft tissue swellings often preceded evident bony change. Leucocytosis was observed in more than half the cases; the serum alkaline phosphatase might be increased and the blood sedimentation rate raised. Radiographic signs began with a subperiosteal shadow, at first on one side but soon surrounding the shaft, frequently throughout its length; the shadow never showed spicules; it was often denser than the shaft, but soon blended with the cortex so that the bone itself appeared large and dense. Later, loss of calcium changed the appearance to that of an enlarged, rarefied bone with a thin cortical shell, with, later still, a gradual return to normal. Sometimes the affected shaft bowed and a tibia had remained so as long as two and a half years. Recovery started in a few weeks or months and was usually complete in about eighteen months or sometimes two years. No treatment affected the course. Biopsies from fifteen cases had thrown little light on causation. There was periosteal proliferation with many osteoblasts forming new bone; in one case the marrow was fibrous and very vascular with many osteoclasts. Inflammatory changes were found twice only. The radiological appearances were distinguished from those of syphilis by the thickness and density of the periosteal shadows and by the absence of metaphysial changes. The present condition usually struck younger children than scurvy, the tenderness was less acute, the whole shaft showed changes, and vitamin C was ineffective. Osteomyelitis had to be considered, especially if few bones were involved. Hypervitaminosis-A, reported in over twenty patients, of one to three years, but not seen in this country, presented tenderness and swelling of one limb or more, with marked

irritability, in one-third of cases pruritis, and often an enlarged liver. The vitamin A in the serum was increased. The subperiosteal shadows were less thick and dense than in infantile cortical hyperostosis and were always smooth. Osteoporosis, as in experimental animals, had been reported. The ulnae appeared to be almost always affected, with the tibiae, clavicles, some metatarsals and ribs next in frequency; only one doubtful case presented a thickened mandible. Stopping the excessive vitamin would lead to recovery. In early gargoylism, Caffey (1951, 1952) had observed subperiosteal shadows in the first weeks of life with some osteoporosis and spurring of the lower ends of the femora.

Swelling of the face at so early an age seemed to be peculiar to cortical hyperostosis, but Jones (1938, 1950) had described a curious condition of familial fibrous dysplasia, which he named cherubism, in a family of Moravian Jews in which the girl and three boys out of four first presented a bilateral swelling of the jaws at the age of two or three years. Radiographs showed cyst-like enlargement of maxillae and mandibles without other skeletal abnormality, and biopsy in one case revealed fibrosis. The swelling increased, demanding cosmetic operation at sixteen to eighteen years of age, and there had been no recurrence four years later. Caffey and Williams (1951) observed five further cases, including a father and son and a mother and son. Jones (1938) had a comparable case traced through five generations.

Engelmann's disease has been recognised widely and called after him in recent years only, though he published his case in 1929. Twenty-three cases have been published. The first case had been seen with Dr Cockayne (1920) at the Hospital for Sick Children thirty-two years ago and was shown by him at the Children's section of the Royal Society of Medicine. It was in a weak, mentally dull boy of nine years, with hyperostosis of the femora, tibiae, one fibula and both humeri, thickening of the frontal regions, and increased density of the base of the skull. The condition was commoner in males and usually in childhood. Familial affection had occurred in two out of twenty-four patients, among whom fourteen were under ten years of age and five between twenty and thirty. Pain in the legs, weakness, difficulty in walking and waddling gait might be complained of. Some had been thin and long limbed. The thickening of the long bones might be palpable. Various neurological signs had been reported, seemingly not significant. One patient had an enlarged spleen. The essential feature was bilateral hyperostosis of the shafts of the major long bones without epiphysial involvement, in this order of frequency: femur, tibia, humerus, fibula, radius and ulna. Both clavicles were reported thickened in four cases, some metacarpals in one, metatarsals in none. Increased density and frontal thickening had been found in seventeen skulls of twenty-four patients, but thickening of the mandible was seen in only one. The fusiform enlargement of the long bones only exceptionally showed roughening. At least six cases presented a double enlargement of each femoral shaft, the larger one involving the lower two-thirds or more, with a much smaller second enlargement in the upper third. Biopsy in ten cases threw no light on etiology, the changes amounting to sclerosis. The hyperostosis invaded the marrow as well as being subperiosteal. In one case cortical bone was replaced by cancellous bone. The fatty marrow showed some fibrosis. The periosteum was thickened, and there might be some thickening of vessel walls in the adjacent soft tissues. In cases followed up the changes have slowly increased. The speaker agreed with the suggestion of a congenital fault though bone changes might not be recognised for some years.

Another obscure affection particularly of the shafts of long bones was melorheostosis, which was not always recognised. Seventy cases had been reviewed. Typically the bone changes were confined to one limb, with pain and sometimes limitation of joint movement. This might be partly accounted for by neighbouring fragments of bone in the soft tissues and by scleroderma. Distortion of a finger or two had been noticed at birth in three cases. Any combination of limbs might be affected, even all four. The distribution did not follow the arterial or nervous anatomy of the limb. Occasionally changes had been found in the sacrum, vertebrae, skull and ribs. McCarroll (1950) found three cases in about a hundred cases of neurofibromatosis. In the epiphyses the increased density might take the form of dots and splashes closely simulating osteopoikilosis, in which, however, they were seen in all the major epiphyses and also in the ends of the diaphyses and there was often a familial incidence, absent in melorheostosis. Biopsies revealed sclerosed and normal bone, overcrowding of lamellae irregularly arranged, and, in only three cases out of fourteen, marrow fibrosis. Putti's supposition of ischaemia from local autonomic disturbance had not been generally accepted.

Another curious affection of the shafts of long bones—important because of confusion with sarcoma, which might be distinguishable only by biopsy—was hyperplastic callus formation. This occurred usually in cases of osteogenesis imperfecta, occasionally without a causative fracture or even without obvious trauma. It might follow fracture of one bone while fracture of another might unite at the same time without excessive bone formation. Early callus might be excessively

dense. Bony excrescences on the long bones might be found, notably on the interosseous borders of the forearm and leg bones. The new tissue infiltrated the adjacent muscle. Biopsy revealed oedema and muscle destruction near the surface of the mass; beneath this mucoid oedema, cellular proliferation and early chondroid formation; deeper still chondroid tissue containing islands of true cartilage; finally trabeculae of calcified woven bone and calcified cartilage (Baker 1946). Mucoid and chondroid tissue were absent from normal callus. An undoubted case was published by Battle and Shattock in 1908.

Radiographs rather suggestive of hyperplastic callus were found in parosteal osteoma of bone, of which sixteen cases had been reported by Geschickter and Copeland (1951). These more localised tumours, usually situated on the popliteal surface of the femur, grew more slowly than hyperplastic callus but might recur after excision. The pathological appearances varied from those of spongy osteoma to low-grade fibrosarcoma.

Finally the speaker recalled a rare type of metaphysial lesion described by Jansen (1934) as metaphysial dysostosis, but a like case studied by Müller and Sissons (1951) had shown histological changes in the bone consistent with renal rickets and secondary hyperparathyroidism, though unfortunately the parathyroids and kidneys were not available.

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ROYAL COLLEGE OF SURGEONS OF ENGLAND

FILM DISPLAY

Development of plasma substitutes—*Professor A. M. Boyd*, Professor of Surgery at Manchester University, gave an introduction to the film "Dextran—the new narrow fraction," shown at the Royal College of Surgeons, Lincoln's Inn Fields, London, on May 20, 1953. Over two hundred surgeons and anaesthetists were present. The film, which is sponsored by Benger Laboratories Limited, describes the progressive selection of the clinically optimal range of dextran molecules contained in "Dextraven," a new form of Dextran, which it is claimed obviates the drawbacks of colloidal solutions previously available for use in place of blood or plasma for blood volume restoration.

Professor Boyd recalled that the problem of providing and conserving adequate supplies of human blood and plasma was one that had engaged the attention of medical scientists since the earliest attempts at blood transfusion. In more recent times intensive research into the possible use of synthetic colloids which could, in certain circumstances, be used in place of blood or plasma, had been undertaken. Several colloids had been suggested and used in patients to combat shock due to loss of blood or serum. These ranged from gum arabic, first employed towards the end of the first world war, to polyvinyl pyrrolidone, the plastic discovered by the Germans and used by the Wehrmacht in the second world war. One of these colloids—dextran—had been found suitable for extensive clinical investigation. It was produced in crude form by a special strain of bacteria from sugar solutions, and it could be purified into a syrupy liquid of about the same viscosity as human blood. The aim of recent work had been to ascertain the type of dextran solution that would be most suitable for infusion into patients suffering from shock due to loss of blood. Firstly, it was necessary to discover the fate of dextran following infusion, and, secondly, to discover ways and means of producing the most suitable solution for routine use.

Crude dextran, a polymer of glucose, possessed molecules with a molecular weight of many millions. Such molecules produced toxic reactions. Careful fractionation was necessary to reduce the molecular weight to a few thousands, which was the most suitable therapeutic range.

Molecules below a weight of approximately 50,000 were rapidly excreted from the body and, therefore, failed to increase blood volume—the essential requirement in the treatment of shock. Indeed, in view of the high water holding capacity of these comparatively small molecules, they could actually deplete blood volume further by carrying water out of the circulation.

Molecules of molecular weight between 50,000 and 130,000, though too large to be excreted in the urine, nevertheless left the circulation and entered the tissue fluids. Here they continued to exert their water holding capacity and, like the smaller molecules, tended to produce the opposite effect to that desired.

Only molecules between 130,000 and 250,000 were suitable and were retained in the circulation for a sufficient length of time to raise and maintain blood volume.

There was every prospect that narrow fraction dextran would revolutionise supportive therapy, conserve supplies of blood and plasma at home for those special cases in which these are essential, and prove invaluable overseas where blood banks are few and far between.

CANADA

THE REHABILITATION OF INDUSTRIAL INJURIES IN ONTARIO

*Dr A. Zinovieff** and *Dr B. H. Young*,† of the Canadian Workmen's Compensation Board's Rehabilitation Centre at Malton, Ontario, have sent a report of the development and present state of industrial rehabilitation in the province. Ontario covers an area about eight times the size of England and has a population of four and a half millions, over one million of which is concentrated in Toronto (Fig. 1).

Workmen's compensation—Beginning in 1910, by Royal Commission, Sir William Meredith investigated various types of workmen's compensation administration in North America, Britain and Continental Europe. As a result of this study the present Act‡ was framed. It provides better recompense to workmen injured at their employment. It extends protection to all accidents sustained at work, instead of only to those caused by negligence on the part of the employer. It prohibits private litigation for damages. It ensures prompt and certain payment direct to the injured workman or his dependants. It places the adjudication of claims in the hands of the Workmen's Compensation Board, instead of the Civil Courts, and in most of the industries to which it applies it makes the employers' liability mutual instead of individual.

FIG. 1
Map of Ontario.

The Workmen's Compensation Board is made up of a Chairman, Vice-Chairman and Commissioner, who are appointed by the Provincial Government. Their duty is to interpret and administer the Act. Broadly speaking the Act provides for a compulsory insurance scheme that covers all industries engaged in manufacturing. Certain other employers such as retail businesses or farmers may also join this compensation scheme by application; only domestic servants are excluded. The annual rate the employers pay into the Board's accident fund is based on their assessable pay-roll and on their previous year's accident experience. The accident fund provides money for the compensation of the injured workmen, for all medical aid payments, for pensions, and for the Board's salaries and administrative expenses. An employee of the covered firms is entitled to compensation up to 75 per cent of his earnings to a maximum of $4,000.00, provided that he has been injured at work and that he is off work for five days or more.

Development of rehabilitation services—The Act provides "that the Board may take such measures and make such expenditures as are deemed necessary or expedient to rehabilitate injured workmen." Some physical medicine was made available in 1933, when a single room at the Board's offices was used to provide electro-therapy and massage. Within a year it was necessary to increase this space, and in 1935 an out-patient clinic was established in the heart of the city of Toronto, providing facilities for physical medicine which included physiotherapy and introduced occupational therapy. These facilities showed increased usefulness in the treatment of the injured patient, and with the increasing growth of industry as well as of the services provided, an average of approximately 200 patients per day was being treated. Dr H. D. Storms§ was then director of this programme and under his leadership the use of occupational therapy in the rehabilitation of the injured was greatly developed. Certain disadvantages of out-patient treatment became apparent, particularly for those patients brought into the city from outlying parts of the province, and in 1947 it was decided to start a residential rehabilitation centre and a move to the present premises at Malton was made.

The rehabilitation centre—The Centre is situated eighteen miles form Toronto on the edge of the city airport (Fig. 2). This situation is rather too far from the city and it is considered that a rural site outside the city limits would be better.

* Director of the Division of Physical and Occupational Therapy, University of Toronto.
† Medical Superintendent, Workmen's Compensation Board's Rehabilitation Centre.
‡ Workmen's Compensation Act (1915), Ontario.
§ STORMS, H. D. (1950): *In* The Principles and Practices of Rehabilitation, p. 132. Edited by H. H. Kessler. Philadelphia: Lea and Febiger.

There are two treatment units in the Centre—a hospital section and a clinic section. The hospital section has 190 beds and is used to house and treat not only bed patients, but also those who need help with self care, those who are on crutches and those who cannot manage stairs. The latter two groups are there because there is no covered way connecting the living quarters of the clinic section to the main treatment block, and this is necessary in the snow and ice of winter. Two sunrooms are used for early gymnasium classes; there is a screened room for short wave diathermy treatments (also used for electromyography) and a room for craft work for the up-patients.

The clinic section consists of a treatment block providing physiotherapy, remedial gymnastics and occupational therapy, as well as consulting rooms and secretarial offices. Its 315 patients are housed on the upper floors of the hospital section and in two buildings adjacent to the main treatment block. Recreational facilities include cinema and variety shows, bingo and card tournaments and games such as darts, billiards, etc. A library also is available.

The patients—The patients are drawn from all the industries in the province that come under the Act and most of them are from heavy industries. They represent many different nationalities, many being recent immigrants from European countries, and an increasing number of them do

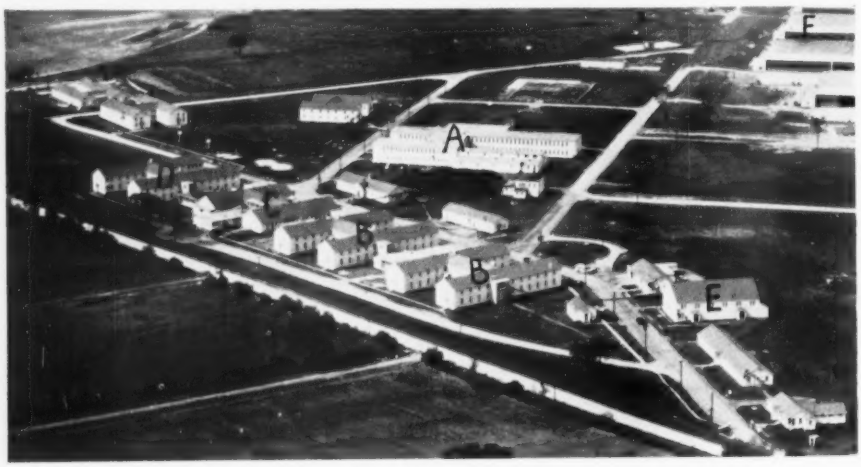

FIG. 2

Aerial view of the Centre. A—Clinic treatment block. B—Hospital section. C—Administration building. D—Clinic patients' quarters. E—Theatre. F—Aerodrome.

not speak or even understand English. This complicates the problem of rehabilitation, as the medical officers, unless they are accomplished linguists, have to rely a great deal on interpreters and there is no "personal touch" in this method of communication.

In the year 1952 there were 209,974 industrial accidents reported in the province. Of these, 56,508 resulted in an absence of five days or more from work; from this group, 3,736 (15 per cent) patients were admitted to the Centre. They stayed there an average of six weeks each and 80 per cent returned to their former work.

Treatment arrangements—Patients are transferred to the Centre either at the recommendation of their own surgeon or in some instances at the recommendation of the Board's medical officers. They come from all over the province and consist mainly of longer term cases; some short term cases come from Toronto and its environs.

The Board had had to do a great deal of education of the profession at large in getting them to accept the principle that rehabilitation begins as soon as the patient has been injured, and that transfer to a rehabilitation centre should take place as soon as the fracture is uniting satisfactorily; or, in the case of surgical operations, as soon as the wound is healed and some objective of physical recovery can be worked on—so much better than leaving it to the stage when the psychological outlook of the patient has reached one of stubborn pessimism and relatively intractable apathy! This situation has gradually improved over the years, but still about one-third of the patients admitted to the clinic section arrive more than a month beyond what would have been an obviously reasonable time for transfer. More time is also lost by the fact that, as yet, adequate facilities for physiotherapy in general hospitals are not too common.

The surgeon referring the case is notified of progress every two weeks by letter and is always consulted in case of any difficulty. The surgeons are encouraged to visit the Centre and, to encourage this further, a clinical conference, run by the orthopaedic surgeon, is held once every two weeks, and is open to all surgeons who care to come.

Treatment team.—In addition to the medical superintendent, who is a specialist in physical medicine, a full time orthopaedic surgeon and a part time consultant in physical medicine, there are eight full time medical officers, two of whom are certified specialists in physical medicine and two others in training. It has been found that, with untrained medical officers, it is impossible to operate efficiently if the number of patients per doctor rises much above fifty; this is in accord with Watson-Jones's* war-time recommendation for the Royal Air Force rehabilitation centres. Even with skilled medical officers the number cannot rise above seventy without loss of attention to the detail on which good rehabilitation depends.

The Centre employs twenty-one physiotherapists, eight in the hospital, and thirteen in the clinic; twenty-one occupational therapists, four in the hospital and seventeen in the clinic; and eight remedial gymnasts, two in the hospital and six in the clinic section.

Fig. 3

Physiotherapy: instruction in active movement—the keynote.

Treatment programme.—In the hospital section the medical officers do rounds with the therapists and charge nurse attached to their wards once a week. An individual programme is prescribed and this varies according to whether the patient is bedfast or not. If not, he may attend one or two classes daily with a remedial gymnast, as well as having individual treatment from the physiotherapist and occupational therapist. The classes are arranged anatomically: thus there are arm, back, foot and ankle, hip and knee and walking re-education classes. Whether the patient is up or not, both the morning and afternoon programmes start with bed exercises in the ward taken by the physiotherapist. The bed patients are encouraged to do "key" exercises every hour, and an electric clock system rings a bell in each ward every hour to remind them.

By the time the patient is transferred to the clinic section, he is ready for a full or nearly full day's programme. The clinic day is a six-hour one; all this time is spent on actual treatment divided between physiotherapy, occupational therapy and remedial gymnastics. There is, however, a "diversional" room in the occupational therapy department, which is used to give rest periods. A patient for whom diversional occupational therapy has been prescribed rests his injured part while occupying his mind. This is better than providing sitting room facilities which the patients would tend only to usurp.

Physiotherapy and remedial gymnastics follow a conventional pattern. Active movement is the keynote of both (Fig. 3). The usual arrangement of individual work by physiotherapists and group work and games (Fig. 4) by remedial gymnasts is followed, though the latter also look after individual muscle building exercises using weights. Several methods of these are used, including

* Watson-Jones, R. (1943): *In* Rehabilitation of the War Injured, p. 424. Edited by W. B. Doherty and D. D. Runes. New York: Philosophical Library.

those described by de Lorme* and by Zinovieff.† In the physiotherapy department various forms of heat are usually given as a preliminary to exercise or as a means of pain relief, but massage is seldom prescribed and hardly ever continued for more than two weeks. It is used mainly to loosen recent scars, or to help get oedema rapidly under control. Electrical stimulation of denervated muscles is given as a routine. Occupational therapy takes the most space and is also somewhat unconventional. In addition to the usual craft techniques such as weaving, basketry, metal work and carpentry, the occupational therapists are responsible for certain remedial games, such as shuffleboard, darts, bowling and badminton, and also for an industrial section, which is designed

FIG. 4

Remedial gymnastics: group exercises in later stages.

FIG. 5

Occupational therapy: vocational preparation.

to meet the special needs of the group of patients that are being rehabilitated at this Centre, and to provide for their vocational preparation and work assessment. Thus patients may be seen building walls, shovelling, sawing, logging (Fig. 5), or track laying.

Resettlement—If a patient is fit to return to his own job the ideal of rehabilitation has been achieved; if not, a final problem arises. It is complicated in this province by the absence of legislation such as the Disabled Persons (Employment) Act (1944) in Great Britain; by the difficulty of obtaining

* DE LORME, T. (1946): Progressive Resistance Exercises. Archives of Physical Medicine, **27**, 607.
† ZINOVIEFF, A. N. (1951): Heavy Resistance Exercises—The "Oxford Technique." British Journal of Physical Medicine, **N.S. 14**, 129.

lighter work when so many relatively or completely isolated communities depend only on heavy labour; and lastly, by the fact that so many of the patients lack either the intelligence or educational background to do other than heavy manual labour, or to justify vocational training.

The Board has a department that deals specially with these problems and its representative is attached to the Centre. He sees all patients on admission, and when the medical officer's notes inform him that there is a likelihood of sufficient permanent disability to require a change of job, he investigates other possiblities, either with the patient's employer or within the patient's community. These are noted and discussed between the medical officer in charge of the case and himself when the patient's treatment is nearing completion. In many instances a successful placement can be made; in a few, vocational training may be recommended and paid for by the Board. However, the function of this department is somewhat limited by the fact that the Act does not make the Board responsible for resettling a disabled patient, but only for helping in the process; the final responsibility being the patient's. So far the Board has not established any sheltered workshop facilities.

When a patient's definitive treatment has been completed, if there is no disability, his compensation payments cease. If temporary disability exists which leads to loss of earnings, either through reduced efficiency or change of job, this loss is cushioned somewhat by a temporary disability rating. This is reviewed at intervals, either until full recovery, or until a state of permanent disability has been reached. In cases of permanent disability a permanent pension is assigned. The amount of pension is based on a rating schedule, though the degree of disability in relation to the patient's own employment is also taken into account. The following figures are examples of this rating schedule: below-knee amputation 40 per cent; above-knee amputation 60 per cent; above-elbow amputation 60 per cent; below-elbow amputation 40 per cent. A permanent pension is effective for life. Lump sum payments are made only on those disabilities in which the pension comes to $10.00 a month or less. On all other pensions payment is made monthly for life.

The authors wish to thank the chairman and members of the Workmen's Compensation Board of Ontario for permission to publish this report.

NEW ZEALAND

NEW ZEALAND ORTHOPAEDIC ASSOCIATION

1952 MEETING

A meeting of the New Zealand Orthopaedic Association was held in Dunedin on November 19, 20 and 21, 1952. Mr Leslie Will, of Christchurch, was elected president in succession to Mr Alexander Gillies, and Mr Rex Blunden, of Christchurch, was appointed Secretary.

Immediate internal fixation of the compound fracture—*Mr A. B. McKenzie* (Christchurch) had tried to overcome the disadvantages of the usual conservative method of management of compound fractures, without exposing the patient to the greater risks of infection, by performing immediate internal fixation of the fragments and at the same time obtaining wound healing by first intention. Provided the case was carefully selected, metallic bodies could be placed in compound fractures without prejudice to wound healing.

If infection was going to supervene it would do so in any case, in which event it would be an advantage to have the fracture already under control. Experimental work on the intramedullary nailing of the grossly contaminated compound fractures had shown that these united more rapidly than control fractures that had lacked the immobilisation of internal fixation. Definite criteria had to be satisfied: there must be no absolute skin loss and primary skin closure must be possible without tension, there must be no gross contamination evident, and above all the open operation must be performed in that golden period of the first six hours, *i.e.*, when many would repair tendons and even nerves, but not bones. With these criteria satisfied, it seemed most desirable to perform internal fixation when the patient had unstable or multiple fractures. Fourteen cases had been treated in this way so far. In all, the wounds had healed well by first intention, and union had occurred or was in the process of occurring.

Review of poliomyelitis epidemic, Auckland (1947-1949)—*Dr A. R. Brown* (Auckland) said that during the epidemic 388 cases were admitted to Auckland Hospital. In the infectious period they were under the combined care of the infectious diseases physician and the neurologist. The physical treatment was supervised by the specialist in physical medicine. After the isolation period was over, the physical medicine department was responsible for further treatment, and the orthopaedic surgeons were consulted regularly and took over when surgical intervention became necessary.

The routine treatment consisted of hot packs in the early stages supplemented, or superseded, by hot baths and accompanied by stretching when necessary in cases of painful tightness. Re-education in those suffering from lower motor neurone paralysis was carried out according to customary methods, and included under-water exercises and muscle training in Guthrie-Smith suspension. Painful muscle tightness occurred in most cases. Splintage was seldom used.

The following is a statistical summary of the epidemic (up to August 1952): Number admitted, 388. Died, fifteen. Average in-patient period, 2·6 months. Average age, ten years. Tightness recorded, 85 per cent. Tightness cleared up (average time), five weeks. Early paralysis, 45 per cent. Final major paralysis, 8·8 per cent. Final minor paralysis, 14 per cent. Scoliosis observed during treatment, 28 per cent. Scoliosis on discharge: major, 1·5 per cent (all spines grafted); minor, 6·2 per cent. No residual disability, 68 per cent. Surgery necessary, 6 per cent.

The high percentage of potential scoliosis in cases which had no sign of paralysis was striking. It was suggested that non-paralytic poliomyelitis is a possible cause of a proportion of cases labelled idiopathic scoliosis.

The management of acute anterior poliomyelitis—*Dr J. E. Caughey* (Otago) discussed at length the treatment of poliomyelitis, prefacing his remarks with a reminder of the manifestations of the disease and our objectives in therapy. He emphasised the differences between muscle tightness, muscle spasm and muscle contracture and stressed the importance of careful clinical examination. Whatever might be the pathogenesis of muscle tightness and spasm, they were significant factors in the disease and treatment in the early stages was directed largely to their relief.

Dr Caughey believed that in epidemics of poliomyelitis patients should be under the care of neurologists, paediatricians and general physicians who work in conjunction with a specialist in physical medicine, rather than the orthopaedic surgeon. The place of the orthopaedic surgeon in the picture was in the field of corrective surgery a year to eighteen months after the acute illness was past.

In the early treatment, tactful and sympathetic handling was of great importance. Patients should be nursed as recommended by Kenny on a firm mattress with boards between it and the springs. The feet should be rested against a foot board four inches beyond the end of the mattress; rotation of the leg was prevented by sandbags or by movable blocks which stood out from the foot board. In this way adequate splintage was obtained without the ill effects of the severe restriction with immobility of a plaster splint. Moist heat was of great value in relieving pain; in the early stages hot moist packs were extensively employed; later hot baths were effective in loosening muscle tightness and enabling passive and active movements to be carried out.

Passive movements were begun in the acute stage of the disorder as soon as the temperature had settled. Physiotherapists worked as a team with the "packers" and after the packs were removed passive movements of all joints were carried out short of pain. When severe pain had settled down, active movement and stretching of tightened muscles might be commenced. Training in gait was important in order to maintain a correct pattern of walking and other movement. The methods advocated were essentially those developed by Kenny. These methods were now in use in most centres in the United States and in some centres in New Zealand.

Muscle biopsy—*Dr Barbara F. Cubit* (Dunedin) presented a preliminary report on a series of biopsy specimens taken from skeletal muscle at the site of previous operative damage, and also at various distances from the initial operation site. An attempt was made to ascertain the extent of the damage to muscle that might be expected following routine operative procedures. In the preliminary series it was found that there were indications of muscle damage as far as four centimetres from the initial operative incision. The commonest lesion was fibrosis between the muscle fibres accompanied by degeneration of the fibres, and patchy round cell infiltration. These lesions were attributed to damage to the arterial blood supply associated with the previous operation. Seemingly the collateral blood supply in these areas was inadequate.

Nuclear herniations of the intervertebral disc—*Dr A. C. Bigg* (Dunedin) described the features of four distinct types of intervertebral disc lesion, with special reference to their radiology. 1) *Herniation of the nucleus pulposus into the vertebral spongiosa:* These herniations—Schmorl's nodes—in the adolescent, resulted in the thoracic or upper lumbar kyphosis of Scheuermann's disease. In older persons they might extend and lead to collapse of the vertebra. 2) *Nuclear herniation through the anterior part of the annulus:* The nucleus pulposus might protrude forwards to impinge upon the tough anterior longitudinal ligament which deflected the nuclear material caudally to cause a pressure erosion of the anterior superior border of the centrum. These lesions were often mistaken for inflammatory or tuberculous disease. They caused the characteristic vertebral erosion of the first lumbar vertebral body in some types of dyschondroplasia. 3) *Nuclear herniation beneath the epiphysial ring:* The cartilage plate was thin at the junction of the centrum with the epiphysial ring and nuclear material not infrequently burrowed into the vertebra here,

and, as a result of mechanical factors and the firm attachment of the anterior longitudinal ligament, a crescentic fragment of bone separated from the upper anterior margin of the centrum. This appeared in the radiograph as a triangular fragment of bone, the so-called "persistent epiphysis." 4) *Posterior nuclear herniations:* These were well recognised clinically. It was almost always possible by plain radiography and movement studies to indicate the level of the protrusion. By myelography these lesions could be divided into four groups—projections, intermittent prolapses, extrusions and scarred discs.

Anomalous calcaneo-navicular articulation.—*Mr R. H. Dawson* (Palmerston North) briefly discussed the causes of spasmodic flat feet and demonstrated three cases of anomalous calcaneo-navicular articulation. One of these patients presented with the typical symptoms of spasmodic flat feet and was treated by excision of the anomalous bony bridge with a satisfactory immediate result. The other two patients were asymptomatic, one being the father of the first patient and the other being discovered in the routine radiographs after a foot injury; both appeared to have a normally functioning joint between the calcaneum and navicular.

Congenital metatarsus varus.—*Mr William Parke* (Gisborne) presented a series of seventy-five cases of congenital metatarsus varus. He classified cases with this deformity into two groups, mobile and fixed. Attention was drawn to the late age at which these cases were presenting for treatment, as compared with countries elsewhere. The treatment was discussed and half-boot splints were shown, which were used to maintain correction.

Arthrography in congenital subluxation and dislocation of the hip.—*Mr James R. Kirker* described the technique of arthrography and illustrated its use in diagnosis, prognosis and treatment. In approaching the problem of the management of a congenitally dislocated hip one should determine early whether one was dealing with primary subluxation or a primary dislocation of the hip. If established dislocation was present, it was necessary to determine what the pathological anatomy was in the particular case, and whether it was reasonable to expect that conservative reduction by gentle manipulation or frame traction and abduction would be possible. If conditions appeared favourable, conservative methods were employed. If conditions appeared unfavourable, gradual reduction by frame traction was still employed initially, in preference to forced manipulation or open operation, because it sometimes succeeded even in the presence of adverse anatomy, and, even if it did not do so, the stretching of the soft parts would facilitate whatever further form of treatment was decided on. If the dislocation remained unreduced, it was wise to proceed with open operation. If the above approach was correct the only way to implement it scientifically was to employ arthrography freely.

Review of acute osteomyelitis.—*Mr James R. Kirker* reviewed two years' cases of acute osteomyelitis admitted to Middlemore Hospital. The years chosen were 1950 and 1951. The number of cases of acute primary haematogenous osteomyelitis admitted in the year 1950 was twenty-two, and in 1951 thirty-five (the number recorded in 1947 was thirty cases, so that the incidence was unchanged). The average time in hospital was three and a half weeks in 1947, three and a half weeks in 1950, and five and a half weeks in 1951—the increased period in 1951 being due to the routine prolonged course of penicillin. The dosage employed in the 1947 series was 15,000 units three-hourly, and on this dosage the 46 per cent of the patients who were septicaemic took eleven to twenty-one days for the temperature to settle. The time taken for the temperature to settle in 1950–1951 was 5·5 days in cases of comparable severity, and the average dose given was 200,000 units six-hourly. In the 1950–1951 series, there were four acutely ill delirious children after two to three days of treatment, whereas in 1947 a large number of cases were acutely ill for a week or more. It was believed that the larger dosage, and the use of a purer penicillin preparation, were responsible for the different clinical course seen.

Ten cases of the 1950–1951 series underwent surgical intervention (incision of subperiosteal abscesses plus bone drilling) because of failure to show satisfactory response to conservative treatment after three days. In all except one primary skin closure was successful. In the other case healing followed delayed primary closure. So far no patient operated upon has returned with recurrent flares or with chronic infection.

Three patients who failed to settle on three days' conservative treatment did not undergo surgery. Their radiographs still show multiple areas of rarefaction in the bones involved; one sustained a pathological fracture after discharge, and one has a degeneration of the hip joint.

Recurrent dislocation of patella.—*Mr Rex Blunden* described the pathological anatomy, clinical and radiographic features of recurrent dislocation of the patella. He had found that the posterior surface of the patella, instead of having two nearly equal surfaces divided by a ridge, was unequally divided; the medial surface was much shortened, and more nearly vertical. The bone was considerably thicker, and narrower from side to side. In traumatic cases there may be a separated "ossicle" on the medial side. The fascia and joint capsule were abnormally lax on the medial side.

The patella ligament was longer than usual, allowing the patella to ride high on the femoral condyles; it was often attached to the tibia lateral to the line of the femur. The lateral femoral condyle was flatter, and there might be a mild genu valgum. Clinically, subluxation was commoner than dislocation. There was abnormal mobility of patellae, but before mobility is judged to be abnormal the central ridge must pass over the lateral condyle. The patella was higher than normal. Subluxation occurred at approximately 45 degrees, and was corrected by extension or further flexion. The patellar tendon had an unusually lateral insertion. Radiographically the features were: high patella; unequal facets, the medial smaller and more vertical; thickened squat patellae; and often a detached ossicle on the medial side. Axial projections should always be made.

DENMARK

DANISH ORTHOPAEDIC ASSOCIATION

1953 MEETINGS

A meeting of the Danish Orthopaedic Association was held in Copenhagen on February 28 and March 1, 1953. The main topic was the treatment of poliomyelitis.

Orthopaedic treatment of poliomyelitis—*E. Thomasen* (Århus) gave a survey of the principles in the orthopaedic treatment of poliomyelitis, and his collaborators reviewed the results obtained at the Orthopaedic Hospital in Århus.

Management of paralytic feet—*E. Hjalmar Larsen* (Århus) reviewed 253 cases of paralytic feet, ninety-eight having been treated by tendon transference with or without additional soft tissue operations, sixty-three by lengthening of the calcaneus tendon, and 100 by arthrodesis. Concerning cases of tendon transferences—almost all done in childhood—no effect was seen in activation of the triceps surae, in the other groups good or improved results were seen in almost half the cases. It was mentioned that in only seventeen cases was the transference done within two years after the infection, and in forty cases not until five years after or even later. In the discussion on this paper it was stressed that a tendon transference should be performed early, direct fixation into bone should be done and post-operative bracing maintained for years. Forty-seven panarthrodeses, twenty-nine ordinary triple arthrodeses and sixteen Lambrinudi arthrodeses had been performed with very few bad results.

Tendon transfer for quadriceps paralysis—*Ib Christensen* (Århus) reviewed forty cases of tendon transference for weak quadriceps and found a satisfactory result in half the cases. He also reviewed thirty-nine cases of operation to restore opposition of the thumb. Some degree of function was obtained in twenty-nine cases and it was classified as satisfactory in sixteen cases.

Retraining of weak muscles—*N. Bukh* (Viborg/Århus) had studied the regeneration under training of muscle power in five different muscle groups. The muscle strength was tested by the accepted classification from 0 to 5. Out of 318 0-muscles 70 per cent were still 0 after two years, only 13 per cent became 3 or more. Among seventy-one 1-muscles 64 per cent, and among seventy-one 2-muscles 74 per cent, gained strength of 3 or more.

Other papers—*W. Permin* (Copenhagen) gave an account of the prognosis for scoliosis based on a study of 357 cases recorded by the Disablement Insurance Board. Seventy-six per cent of 195 patients were recorded as having died from heart or pulmonary complications at an average age of 48·5 years. Those who died from other reasons averaged 55·6 years of age. *E. Thyge Madsen* (Copenhagen) reported an investigation of birth fractures and emphasised the importance of perfect reduction and retention in all cases except fractures of the clavicle.

Clinical cases and films—From the Orthopaedic Hospital in Copenhagen cases of poliomyelitis and films were demonstrated to illustrate results of various treatment by *Sv. Kiær, K. Jansen, B. Suvy* and *K. Bang Rasmussen*.

The spring meeting was held in Copenhagen on April 25 and 26, 1953.

Compression in fracture treatment and arthrodesis—*R. Movin* (Copenhagen) gave a preliminary report of treatment by compression methods in seventeen cases of fractures, pseudarthrosis and joint fusions.

Overgrowth of leg complicating neurobfiroma—*I. Lou* (Kolding) described a case of a neurofibroma localised to the trochanteric-pelvic region with overgrowth of the leg. The tumour had been excised.

Sarcoma of the extremities—*O. Nygaard* (Copenhagen) reported fourteen cases of sarcoma of the extremities operated upon at the Orthopaedic Hospital, Copenhagen. It was felt that operation was justified in such cases as some patients could survive for years thereafter. The operation should be radical, for some patients had had to undergo several operations.

Spondylolysis—*P. Lütken* (Ålborg) gave an account of seven cases of spondylolysis, in three of which there was also spondylolisthesis, seen among twenty-five patients who had previously sustained fractures of the spine. He believed in the possibility of a traumatic origin of the defect in the neural arch.

Arthroplasty of the knee—*Sv. Kiær* (Copenhagen) gave a preliminary report on fourteen cases of knee arthroplasty with acrylic prostheses. It was too early to evaluate results but the procedure was considered promising.

ORTHOPAEDIC APPOINTMENTS

Dr E. Thomasen has been appointed surgeon-in-chief to the Orthopaedic Hospital in Arhus in succession to Dr P. G. K. Bentzon who has retired owing to ill health. *Dr Arne Bertelsen* has been appointed to Department I, the Orthopaedic Hospital, Copenhagen, in place of the late Dr Aage Berntsen.

Two new appointments have been made as chief of the physiotherapeutic departments in Copenhagen/Søllerød and Århus/Hald, *Dr Jens Bang* and *Dr Niels Bukh* being appointed. An orthopaedic clinic has been opened in Odense—the "capital" of Funen—under the leadership of *Dr Aage Randlov-Madsen*.

DEVELOPMENT OF ORTHOPAEDIC CENTRES

Owing to the need of hospital beds during the recent large epidemic of poliomyelitis a country branch of the Orthopaedic Hospital in Copenhagen has been established by the purchase of the large seaside hotel in Hornbæk, the leader of the physiotherapeutic work there being *Ole Renvig*. A cerebral palsy clinic has been opened at the Orthopaedic Hospital in Copenhagen, the children being examined by a team of doctors who include *Dr Sv. Brandt* (neuropaediatrician), *Dr Jens Bang* (physical medicine), *Dr J. Mortens* (orthopaedic surgeon), *Dr Westergaard-Nielsen* (neurosurgeon), *Dr Anna Frandsen* (ophthalmologist), and *Dr A. Arnfred* (psychiatrist). A cerebral palsy clinic in connection with the physiotherapeutic department of the hospital is already established and includes a kindergarten. Additionally a children's home and a residential school for cerebral palsied children has been opened in Søllerod outside Copenhagen. Last year Professor Temple Fay, of Philadelphia, Pennsylvania, and this year Professor R. P. Schwartz, of Rochester, New York, spent some months at the Orthopaedic Hospitals and have given valuable instruction concerning the screening and treatment of cerebral palsied children.

Book Reviews

POLIOMYELITIS. By W. Ritchie Russell, C.B.E., M.D., F.R.C.P., Consultant Neurologist to the United Oxford Hospitals, Consultant Neurologist to the Army. 9 × 6 in. Pp. vii + 84, with 29 figures and five tables. Index. 1952. London: Edward Arnold & Co. Price 14s.

This book, which is something of a landmark in the modest British literature of poliomyelitis, must be put in its setting. For over a century orthopaedic surgeons have been dealing with poliomyelitis as a crippling disease; they were familiar with the appalling deformities that it can cause and became skilled in their correction. Then, after the first world war, legislation on the care of children, together with the teaching of Robert Jones and Girdlestone, opened the way for the prevention of crippling of all kinds. Clinics attached to orthopaedic hospitals enabled orthopaedics to be taken to the patient and so made it possible for treatment to be started before the great crippling diseases of childhood—joint tuberculosis, poliomyelitis and rickets—had caused serious deformity. At the same time there was growing interest in recovery from poliomyelitis during the convalescent phase, and it became customary for orthopaedic centres throughout the country to admit children and adults within a few weeks or months of the onset of the disease. Consciousness of the ever-present menace of deformity led many surgeons to rely on splints as a means of preventing it, and it was some time before the evil effects of the fixation that usually went with this type of treatment were fully appreciated. However, more rational methods were developed with the object of preserving mobility. Thus it may be said that the interest of orthopaedic surgeons in poliomyelitis started in reverse. They were concerned first with deformity and how to correct it, then with methods for its prevention and lastly with the treatment of the disease in its early stages.

The approach of the physician has been different. The order was poliomyelitis as an infectious disease, then as a diagnostic problem in neurology, and lastly as a cause of more or less physical disability. This is well illustrated in the greatest of all the British monographs, that by Batten published in 1916. In the United States Peabody, Draper and Dochez (1912) had already tackled the problem in the same way. Ritchie Russell's essay is in the same tradition and herein lies its value. He has not attempted to cover the subject exhaustively and has dealt rather with those aspects of it that are of particular interest to him. His chapter on the nature of the disease is rightly based on recent American work which is undoubtedly the best of its kind. When he comes to the clinical features of poliomyelitis he speaks from personal experience and this chapter is probably the best of all. It is now known that a number of things influence the site, extent and severity of the paralysis, in particular injury, exercise and certain prophylactic injections. Ritchie Russell discusses all three with authority, and especially his original contribution on the influence of exercise during the pre-paralytic phase. He has also devoted much thought and effort to the care of the patient suffering from bulbar disease and there is no question that if his recommendations are carried out the mortality from poliomyelitis can be appreciably reduced. In the last two chapters he reaches the point where the orthopaedic surgeon usually comes in, namely, the care of muscles and joints and the great problem of rehabilitation. On the basis of Bodian's work he feels justified in starting active exercises at a very early stage, the supposition being that the havoc caused by the virus is over and finished with in a month from the onset of the disease. This hypothesis disregards the histological evidence of other observers such as Einarson; the persistence of abnormalities in the cerebro-spinal fluid; the comparatively long time, about four months, before the electrical excitability of affected muscles becomes stabilised; and the loss of power that has been observed in these muscles after strenuous exercise. The exercises he recommends are pushed to the point of fatigue. On his showing it would appear that this treatment does no harm, but he produces no convincing evidence that it does good, and this work, unlike his earlier investigation of the effect of exercise on the extent and severity of paralysis, is uncontrolled. He has nothing to say about the causes of deformity; this, perhaps, is not surprising, because his study of poliomyelitis has not extended to its late effects.

Serious doubts, such as I myself must feel, about Ritchie Russell's views on the treatment of paralysed and weak muscles, should not blind us to the merits of the monograph as a whole. It is written with clarity and enthusiasm; it should help all of us, in the new responsibilities that recent epidemics have imposed, to recognise poliomyelitis in its early stages, to be on the look-out for and to treat promptly those manifestations of it that threaten life, and to take a more comprehensive view of this sinister and yet fascinating scourge that threatens all civilised communities.—H. J. Seddon.

ANATOMY OF THE AUTONOMIC NERVOUS SYSTEM. By G. A. G. Mitchell, O.B.E., T.D., M.B., Ch.M., D.Sc., Professor of Anatomy and Director of the Anatomical Laboratories in the University of Manchester. Foreword by Sir James Learmonth, K.C.V.O., C.B.E., Ch.M., LL.D., F.R.C.S. (Ed.), Regius Professor of Clinical Surgery and Professor of Surgery in the University of Edinburgh. 10 × 7½ in. Pp. xvi + 356, with 131 figures, many in colour. Index. 1953. Edinburgh and London: E. & S. Livingstone Ltd. Price 55s.

Surgeons and anatomists who have appreciated Professor Mitchell's researches into the anatomy of the autonomic system as they have appeared in anatomical and surgical journals during the past eighteen years will appreciate still more the collected work in one volume, beautifully illustrated and accompanied by a very full bibliography of the subject. The book is an exhaustive study by a master who has not only laboured hard and long at what must often have been tedious and exacting dissection, but who has also achieved a literary triumph by blending his own work with the researches of numerous other workers into a book which is at once scientifically sound, and pleasant to read. He has clearly intended it to be used as a book of reference rather than as a work which will be read from cover to cover, and this has necessitated a certain amount of repetition in order to make every subsection self-contained. We have not been able to discover any omissions, and answers can be found to most of the numerous anatomical problems which students and also surgeons engaged in this particular field have had difficulty in understanding. We are not sure whether Professor Mitchell's views on autonomic afferents can be included in this generally laudatory criticism, for it seems to us clearer to regard fibres originating from dorsal spinal root ganglia or their homologues as distinct from autonomic fibres, even though they may be bound up together in the same nerve bunch. It is interesting that his argument for regarding visceral afferents as autonomic afferents is the only section of the work in which his style, generally most pleasing, becomes vehement—somewhat reminiscent of the gesticulations to distract attention from the weaker part of a sermon!

The illustrations, both photographs and drawings, are beautifully clear and do the publishers great credit. Incidentally they convey a sense of satisfaction that the methods of micro-dissection, which have been so harshly criticised by anatomists who ought to have known better, have been so thoroughly vindicated.

There are large portions of the work, particularly those dealing with the cerebral connections of the autonomic system, which are not at present the direct concern of the surgeon, though it behoves him to know something of the higher centres which control the more peripheral portions of the autonomic system upon which he may be operating. The detailed account of these central connections must be of the greatest possible value to neurophysiologists, and to them as well as to clinicians the work can be warmly recommended.—J. Paterson Ross.

FUNDAMENTALS OF CLINICAL ORTHOPEDICS. By Peter A. Casagrande, M.D., and Harold M. Frost, Jun., M.D., Orthopedic Department of Buffalo General Hospital and the University of Buffalo Medical School, Buffalo, New York. Forewords by Joseph S. Barr, M.D., and Frank N. Potts, M.D. 11 × 8½ in. Pp. ix + 582, with 390 figures. Index. 1953. New York: Grune & Stratton. Price $18.50.

In its capacity of an orthopaedic Baedeker this book certainly covers a huge territory but the inevitably short reference to each subject, irrespective of its relative importance, raises each village to the size of a capital city. Only a small portion of the book can fairly be said to concern itself with fundamentals, and such items are neither clearly specified nor treated as fully as they deserve. Among the forty-six pages devoted to many unusual congenital affections, congenital dislocation of the hip is dealt with in four pages containing seven illustrations; the treatment advocated for the condition is almost purely conservative, the use of the arthrogram is not mentioned, and the decision to perform an open reduction of the hip rests apparently on an arbitrary age limit. Spina bifida is rather summarily dismissed as a subject entirely within the province of the neurosurgeon. The general discussion of skeletal tuberculosis contains views which are unexceptionable, but Pott's paraplegia receives scant attention and there is no allusion to the more mechanistic explanation of the condition and the consequent need for surgical intervention. The chapters on affections of bone, tumours and allied disorders are much happier and form a quick and easy source of reference in aiding the diagnosis of less routine clinical problems. Neurology is adequately covered and the

section on cerebral palsy is good and gives a balanced précis of modern views on the subject and recognises that its management far exceeds the scope of orthopaedic surgery.

The diagrams illustrating the second half of the book, which is concerned with trauma, are naive but self-explanatory. The treatment of fractures is made easy by furnishing statutory prescriptions, many of which are not in accordance with teaching in this country; few orthopaedic surgeons here would agree that the ideal internal suture for fracture of the radius and ulna is intramedullary wiring. It is odd that in a chapter on immobilisation there is no mention of the Thomas splint; but the chapter on prosthetics, braces and shoe corrections is very useful. It is regrettable that the guillotine amputation is still advocated as an emergency measure, although wartime experience of pulling down recalcitrant skin to furnish indifferent flaps proved such a nightmare that the operation was shown to be as time wasting and lowering in the patient's health and morale as it is anachronistic.

It is unlikely that this book will have much appeal for the established orthopaedic surgeon, and for the tyro it offers a wealth of material in the form of a treacherous morass through which the narrow path of safety is but faintly indicated.—John M. P. Clark.

FOURTH AND FIFTH REPORTS OF THE MINISTRY OF PENSIONS STANDING ADVISORY COMMITTEE ON ARTIFICIAL LIMBS. Pp. 17, with 3 figures. Paper cover. 1951. London: Her Majesty's Stationery Office. Price 9d.

During the years immediately after the war, the Ministry of Pensions, with an enlightenment not always seen in Government departments, not only empanelled a Standing Advisory Committee on Artificial Limbs, but provided research facilities at Roehampton so that there should be no marking time in the design and manufacture of artificial limbs.

This Committee has done continuous and valuable work, details of which can be found in its five reports so far published. The Research Department has proved so valuable that it has, in the interim, been completely rehoused and re-equipped, and has a considerable staff fully occupied in the improvements in design, materials, production, fitting and usage of artificial limbs.

Of particular interest is the emphasis on suction sockets for above-knee stumps. These sockets were almost abandoned in this country about thirty years ago, but the cause for this failure has now been overcome by improvements in the valve to control the air pressures. Each valve is tested, manometrically calibrated, set and stamped with the individual's own setting, so that postal replacements are possible. The only two limb-fitting centres so far equipped to supply suction sockets are at Roehampton and Leeds.

Much work has been done on corset-fitting for women, various designs of mechanical hands—still an obstinate problem—varieties of appliances for artificial arms, and toilet appliances mounted on rubber sleeves to enable the handless to bath unaided. It is not possible even to list the subjects under review, but it is encouraging to hear that every suggestion for improvement, whatever the source, receives thorough consideration, and, if promising, design, manufacture and testing in prototype.

The advent of the National Health Service laid on the Ministry of Pensions the responsibility of supplying all artificial limbs, more than doubling its obligations, and the wider placing of contracts raised grave problems of standardisation. It is good to read that a special committee has been appointed to collaborate with the British Standards Institution in this matter and we hope for an early report.

Two defects are unfortunate: there is no reference to the problems in fitting children; and the development of laminated plastics in lower limb sockets receives low priority. This might well overcome the difficulty that wooden suction sockets tend to split, though some success here has been achieved with built-up wooden ones; plastics other than polyvinyl chloride are suitable, as Scales has shown.

A final note of commendation and anticipation concerns the punch-card coding that the Committee has instituted. Over 16,000 cases are fully recorded, and the analysis of this material will throw very much light on the problems, both surgical and technical, that are constantly confronting all who are engaged in this work. We look forward to an early authoritative publication, based on these significant statistics, to guide our hands in the treatment of those requiring amputation in the future.—F. G. St Clair Strange.

ROENTGEN DIAGNOSTICS. By H. R. Schinz, W. E. Baensch, E. Friedl and E. Uehlinger. Based on the Fifth German Edition Revised and Enlarged. English translation arranged by James T. Case, M.D., D.M.R.E. Volume I, Skeleton (Part I). 11 × 8 in. Pp. xii + 868, with 1,183 figures, 472 with colour. 1951. London: William Heinemann Medical Books Limited. Price £12.

Volume I of Roentgen Diagnostics is divided into two parts. The amount of material in Part I is immense. It consists of 868 pages of approximately 500 words a page. There are 1,183 illustrations and the price is necessarily high (£12). One-fifth of the volume is devoted to basic radiological principles and normal skeletal structures. The major part covers fractures, inflammatory diseases and congenital anomalies. There are also chapters on atrophy, hypertrophy, dystrophy and circulatory changes. The intention is obviously to provide a book of reference for radiologists and orthopaedic surgeons. In many parts—for example in the chapters on congenital deformities—the mass of detail is greater than the average clinician requires for routine work. This is not a fault; it is an indication of the great care and thoroughness with which the volume has been prepared. The English student will find that he must read slowly. Many words such as infectiosity, anatomicopathologic and brachybasohypophalangia are unfamiliar and the style is taken from the original German. It is refreshing and very instructive to note a classification and approach to disease processes which is new to the reader. The eighteen pages on osteomyelitis form a classic description of the radiological manifestations of the disease and are as good as any previously written. The inclusion of osteoid osteoma and Paget's disease among the inflammatory disorders of bone may be correct but will not have universal approval. There are a few minor faults in the illustrations. Figures 213 and 571 are upside down and Figure 574 shows a radius and ulna not a tibia and fibula. The quality of the reproductions is superb: every print illustrates the essential feature with great clarity. These volumes probably form the most ambitious post-war publications in radiology. A tremendous amount of work has been done in their preparation and they provide the radiologist with an immense store of accumulated knowledge on radiological signs.—F. Campbell Golding.

SOFT TISSUE RADIOGRAPHY. By Arne Frantzell. 9½ × 7 in. Pp. 103, with 37 figures. 1951. Stockholm: Acta Radiologica, Supplementum 85. Price not stated.

This monograph is devoted to one of the many methods used for the production of radiographs of soft tissues. It is a continuation of the method of Laurell, whose work was published twenty years earlier. The technical aspects are analysed and the clinical applications of the method are shown in selected cases. The reticulated pattern of subcutaneous tissues and the vascular network is demonstrated in considerable detail. One application of the method is for the study of muscular patterns in the various dystrophies. In many patients this can be shown on plain radiographs by the presence of interstitial fat in excessive amounts; the effect is intensified by contrast injections.—F. Campbell Golding.

MYOPATHIA DISTALIS TARDA HEREDITARIA. By L. Welander. 9½ × 7 in. Pp. 124, with 31 figures, 9 tables and case histories. 1951. Stockholm: Acta Medica Scandinavica, Supplementum 265. Price Sw. kr. 10.

Myopathy of distal distribution was reported by Gowers in 1902, and also by Spiller in 1907. Since then cases with this diagnosis have been recorded, from time to time, by some workers; whilst others, such as Wilson (1940) and Critchley (1949) have doubted the truth of this diagnostic label which, they thought, might have been wrongly applied to atypical examples of dystrophia myotonica. In this latter disease myopathy of atrophic or pseudohypertrophic type may occur as an ingredient. Welander, in this monograph, has resolved any doubts about the existence of distal myopathy by much careful work. He has shown, not only that myopathy of distal distribution exists, but also that, in Sweden, it is by no means rare.

Between 1939 and 1948 Welander collected seventy-eight primary cases, for each of which a pedigree was drawn up. Field investigations from these pedigrees revealed 171 secondary cases, every patient being personally examined. A further 150 secondary cases were identified but in

these no examination was made. Autopsy was performed on three patients dying from other causes and in none of them was there found any disease of the central nervous system, the nerve roots, their ganglia nor of the peripheral nerves. Muscle biopsies from twenty-six patients showed histological changes characteristic of muscular dystrophy. Electromyography was performed on seventy-one patients with results which Welander considered typical of myopathic degeneration.

From the 249 cases personally examined, Welander was able to reach certain conclusions. like other types of myopathy, this distal form is heredo-familial, a dominant inheritance being usual. In six families the disease was traced through four generations. Males were more often affected than females. Onset was typically between forty and sixty. The upper limbs were the first to suffer, one side often being involved before the other. The intrinsic hand muscles and the long extensors of the digits were early affected. After an interval of several years wasting and weakness appeared in the intrinsic foot muscles and in the dorsiflexors of the toes and ankles. The tendon jerks were usually spared till the later stages, when the ankle jerks would disappear. As in other types of myopathy sensory changes and fibrillation were absent.

Welander points out that differentiation of distal myopathy from peroneal muscular atrophy, motor neurone disease and dystrophia myotonica, should not be difficult. His patient work has facilitated differential diagnosis.—P. H. SANDIFER.

CRITCHLEY, M. (1949): Sir William Gowers. London: William Heinemann Medical Books Ltd.
GOWERS, W. R. (1902): Myopathy and a Distal Form. British Medical Journal, **ii**, 89.
SPILLER, W. G. (1907): Myopathy of the Distal Type and its Relation to the Neural Form of Muscular Atrophy (Charcot-Marie-Tooth Type). Journal of Nervous and Mental Disease, **34**, 14.
WILSON, S. A. K. (1940): Neurology. London: Edward Arnold & Co.

RHEUMATOID ARTHRITIS IN CHILDREN. By Borge SURY. An M.D. Thesis, University of Copenhagen, 1951. $9\frac{1}{2} \times 6\frac{1}{2}$ in. Pp. 93, with 4 figures and 23 tables. 1952. Copenhagen: Ejnar Munksgaard. Price Dan. kr. 10.00.

The primary objective of this thesis was to decide the somewhat debatable point whether Still's disease in the form originally described by him really exists as a well-defined clinical entity in children. For this purpose the records of a series of 151 patients attending Danish paediatric clinics between 1920-1948 have been analysed carefully. The author comes to the conclusion that the clinical syndrome described by Still merely represents the severest cases of rheumatoid arthritis, which occurs in children in a comparatively wide variety of types ranging from a mild affection of single large joints to polyarticular forms accompanied with high fever and glandular enlargement, often suggesting a septic condition of grave prognosis. Although it does not seem possible to confer the distinction of a separate clinical syndrome on the type of juvenile rheumatoid disease described specifically by Still, the author does believe that rheumatoid arthritis in children in its various forms shows differences from the adult type sufficiently definite to merit its separate consideration. After the age of about ten years, however, the disease tends to assume the adult and more predominantly polyarticular form. Pathologically the manifestations do not appear to vary notably between the juvenile and adult types.

The author has also investigated the extra-articular manifestations of rheumatoid arthritis in children, and has described a band-shaped keratitis which is remarkable in being found in the eyes of children without evident impairment of vision. This associated lesion of the juvenile disease has not, he believes, been described in adult rheumatoid arthritis. He also noted in juvenile arthritis the surprisingly high incidence of a chronic serous iridocyclitis of insidious onset. After the age of ten years this condition alters, the inflammatory changes becoming more acute and so more like the iritis sometimes seen in patients with the adult type of rheumatoid disease.

No fresh clue to the etiology has been found. The antistreptolysin titre was raised in 40 per cent of cases; the agglutination reaction for haemolytic streptococci proved to be negative in all patients under ten years of age, and positive in only 8 per cent of patients between ten and twenty years who had been followed up. It would thus seem unlikely that streptococcal infection is intimately associated with "Still's disease." There appeared to be more evidence in favour of the presence of a hereditary predisposition. The difficulties of differential diagnosis are adequately dealt with, and the mode of onset and sex incidence are exhaustively considered. The author's views on prognosis are interesting, because this has, in the past, been considered bad, on account of the lack of conclusive evidence to the contrary. After observation for twelve years, 10 per cent of the present series had become completely disabled, and 18 per cent had died for various reasons,

of which only half can be considered to be directly and undoubtedly associated with the rheumatoid disease. Thirty-nine per cent of the series had however recovered, whilst 32 per cent could conduct normal activities in spite of diminished joint function.

The final section is devoted to a study of cardiac involvement in juvenile rheumatoid arthritis. The author finds evidence, both ante- and post-mortem, that chronic rheumatic cardiac disease may result. This was the unquestionable cause of death in one case, and probable cause in two others. Signs of cardiac disease were found in 7 per cent of the 109 patients subjected to follow-up.—W. S. C. Copeman.

ARCHIVIO "PUTTI" DI CHIRURGIA DEGLI ORGANI DI MOVIMENTO. Edited under the direction of Professor O. Scaglietti, Director Clinica Ortopedica dell'Universita, Istituto Ortopedico Toscano, Florence. Volume 2. $10\frac{1}{2} \times 7\frac{1}{2}$ in. Pp. 410, with bibliography. 1952. Florence: Istituto Ortopedico Toscano. Price in Italy L. 5,000. Price for foreigners $10.00.

The second volume of Putti's Archives is as good as the first; no mean achievement for any journal. Naturally contributors from Florence outnumber those from other centres, but most of Italy is very well represented and there are three papers from Austria and one from Uruguay. The first paper describes the new Orthopaedic Clinic at Pisa, and the vitality of Italian orthopaedics is very well illustrated throughout the whole volume. There are rather more pages on trauma than on all other subjects, but the field covered includes bone physiology, physiotherapy and a good deal of "cold" orthopaedics. The reviewer was particularly interested in a critical study by Piccinini on the treatment of recurrent dislocation of the patella, and in a remarkable account by Calandriello of an arterio-venous aneurysm caused by a poke in the face from an umbrella rib. The abstracts section is very impressive indeed, and the production and illustrations are a credit to the publishers.—D. Ll. Griffiths.

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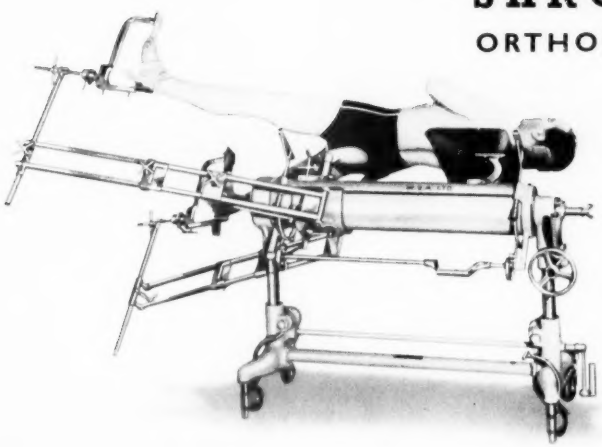

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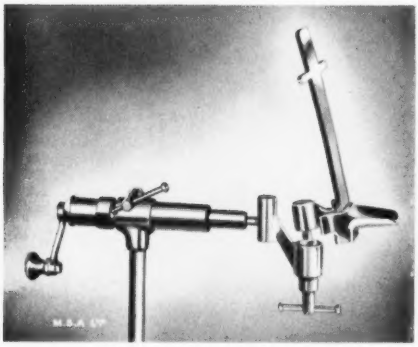

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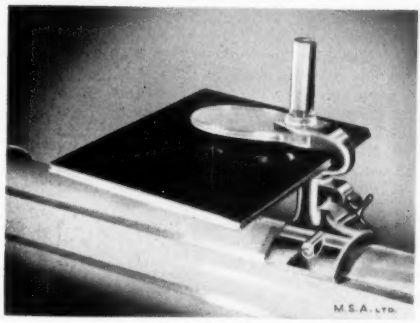

PLASTIC PELVIC REST AND PERINEAL POST

Adapted for radiography of the hip joint, this has provision for a cassette beneath. It is supplied as an extra fitting.

Manufactured by

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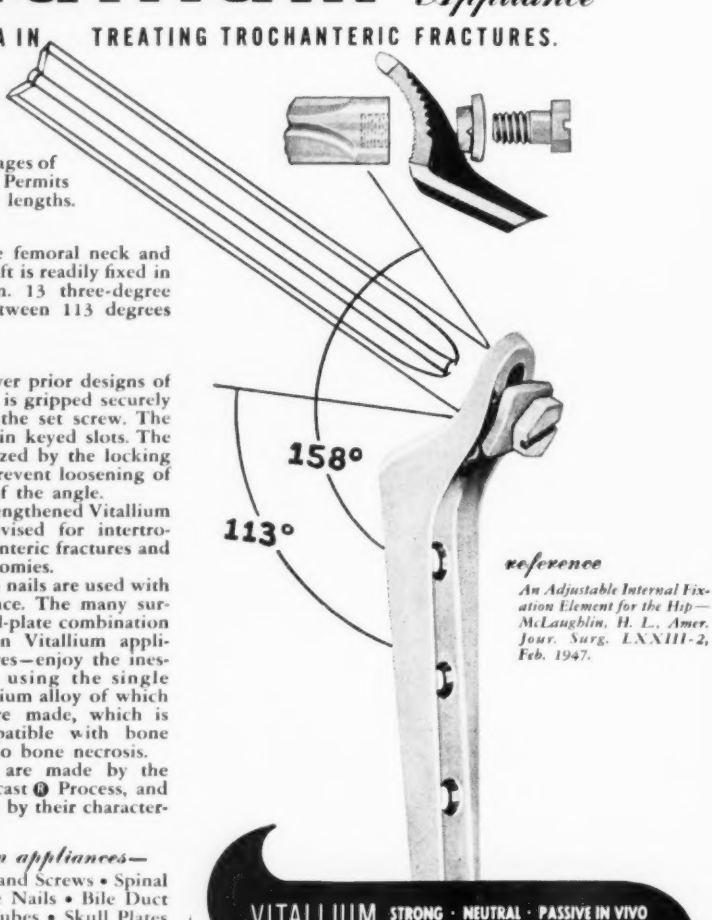
adjustable the Vitallium®

Mc Laughlin Intertrochanteric Appliance

A NEW IDEA IN TREATING TROCHANTERIC FRACTURES.



EASIER INSERTION
Incorporates the advantages of nail-plate combination. Permits wider selection of nail lengths.

ADJUSTABLE
Angular relation of the femoral neck and head to the femoral shaft is readily fixed in most desirable position. 13 three-degree steps are provided between 113 degrees and 158 degrees.

POSITIVE LOCK
An improved feature over prior designs of this appliance. The nail is gripped securely by the plate teeth and the set screw. The locking collar engages in keyed slots. The set screw shaft is squeezed by the locking collar. These features prevent loosening of the screw or collapse of the angle.

This improved and strengthened Vitallium appliance has been devised for intertrochanteric and subtrochanteric fractures and for high femoral osteotomies.

Regular Vitallium hip nails are used with the McLaughlin appliance. The many surgeons who prefer a nail-plate combination can now standardize on Vitallium appliances for all hip fractures—enjoy the inestimable advantage of using the single metal, the cobalt-chromium alloy of which Vitallium appliances are made, which is inert, completely compatible with bone and tissue and causes no bone necrosis.

Vitallium appliances are made by the Austenal-devised Microcast Ⓡ Process, and can be readily identified by their characteristic "satin" finish.

reference

An Adjustable Internal Fixation Element for the Hip—McLaughlin, H. L., Amer. Jour. Surg. LXXIII-2, Feb. 1947.

some other Vitallium appliances—

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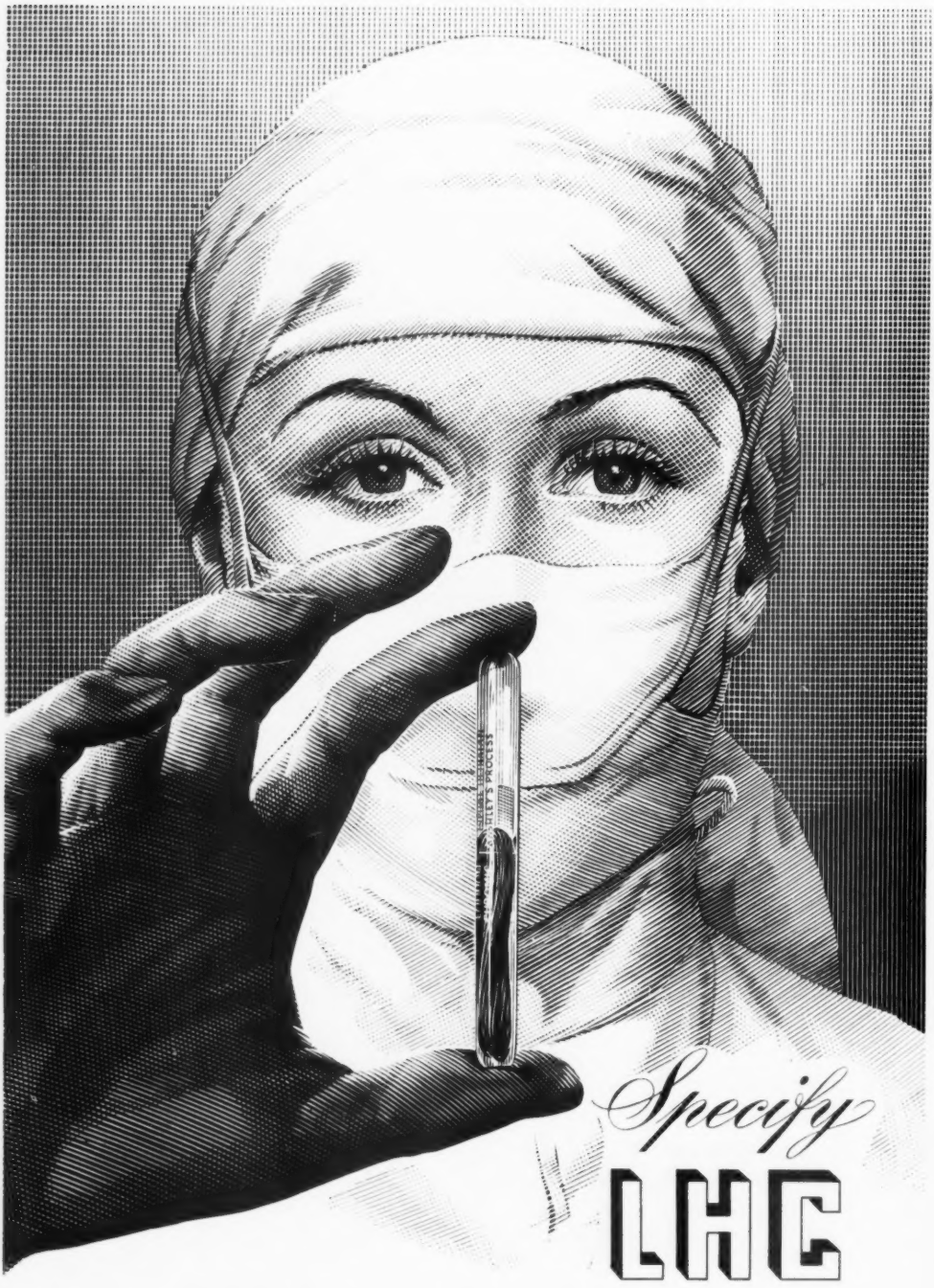

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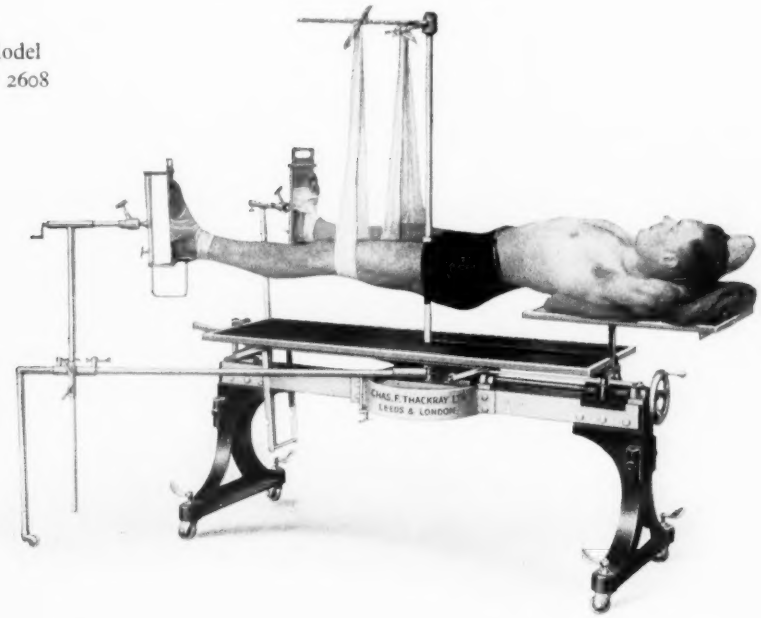

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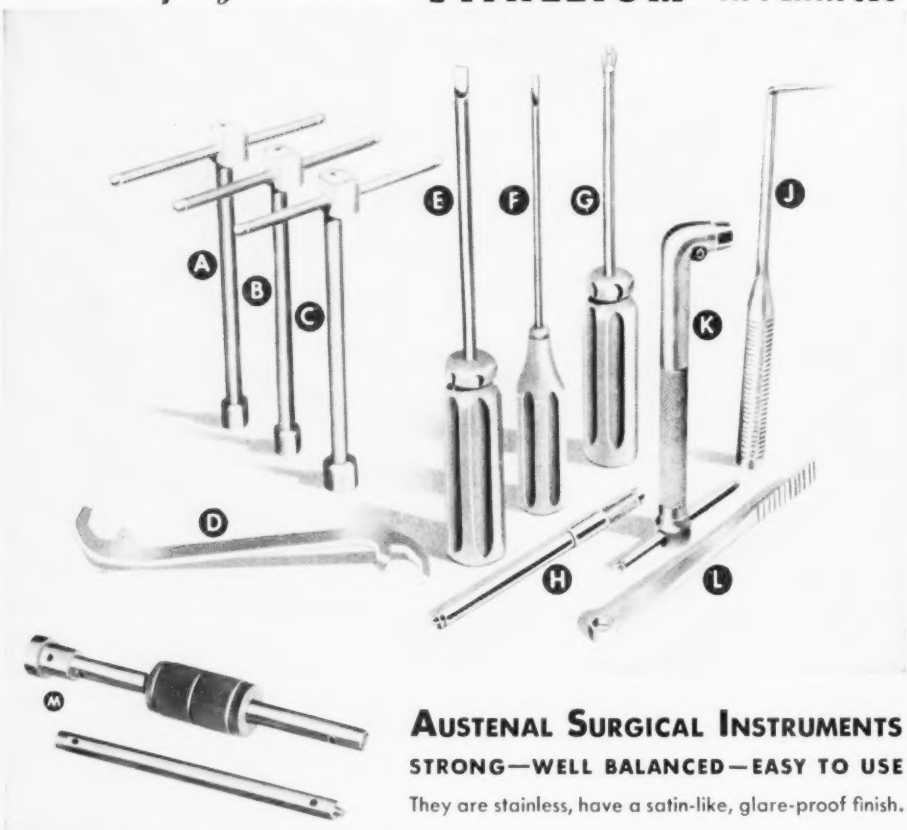

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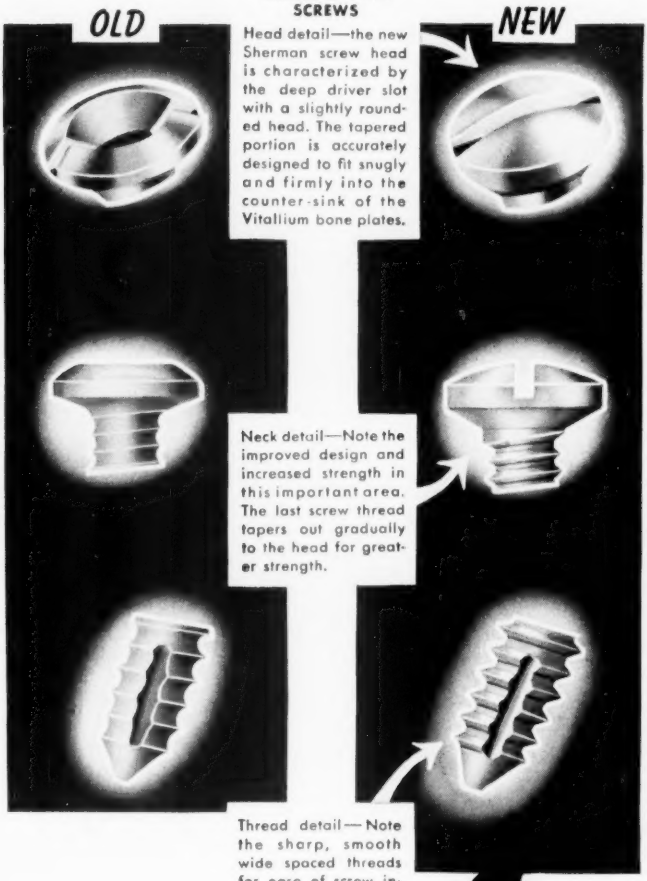

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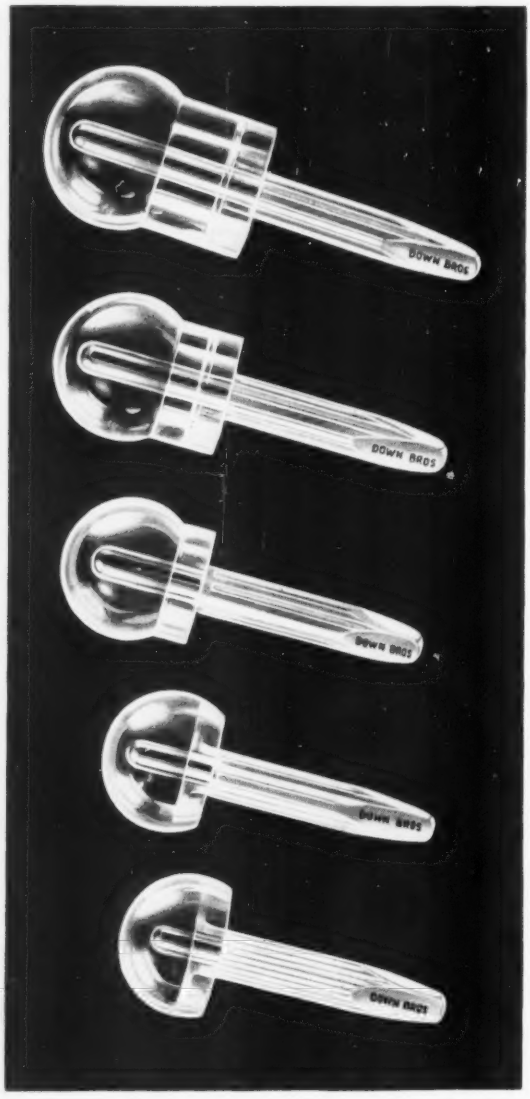

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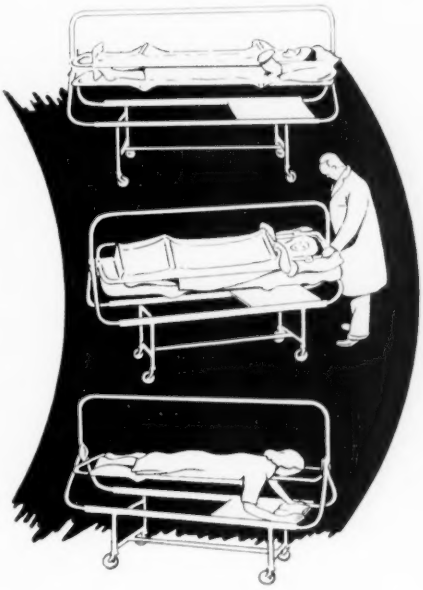

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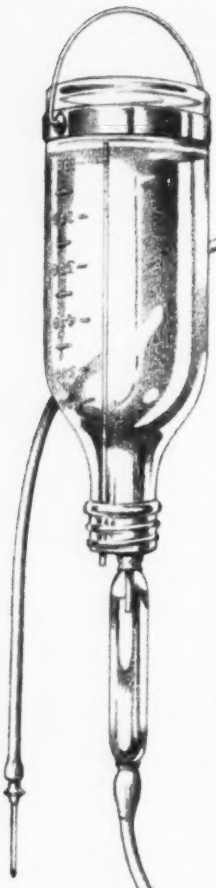

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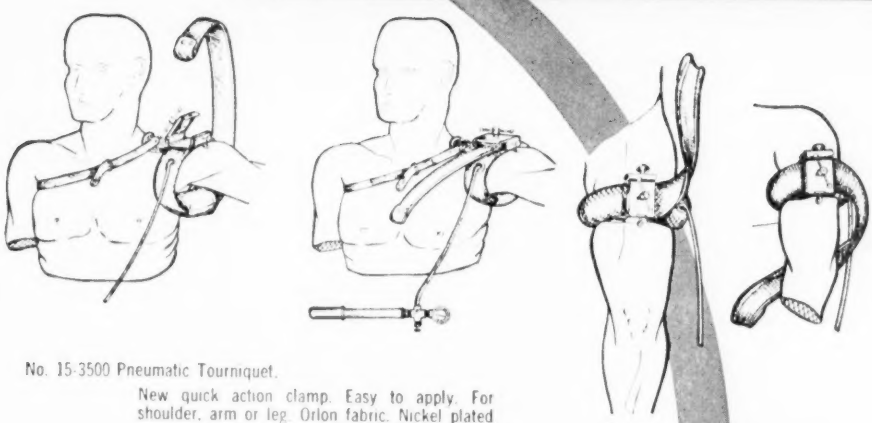

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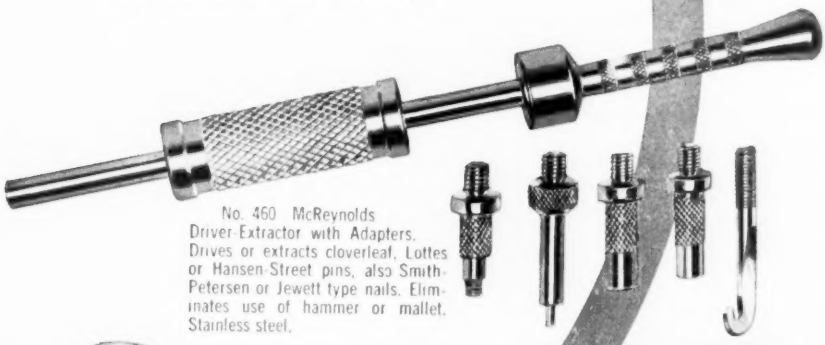

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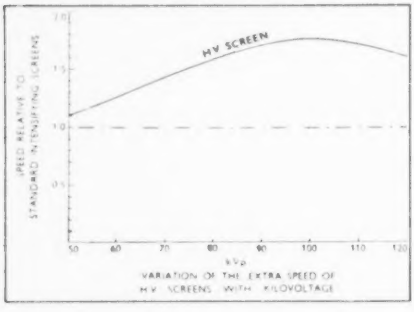

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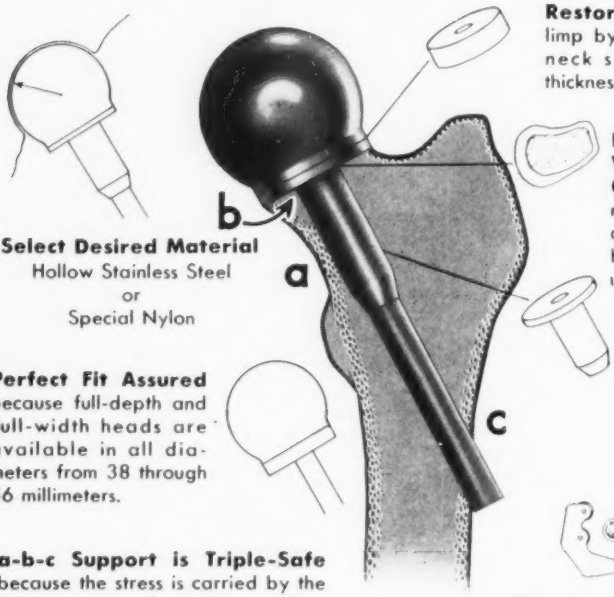

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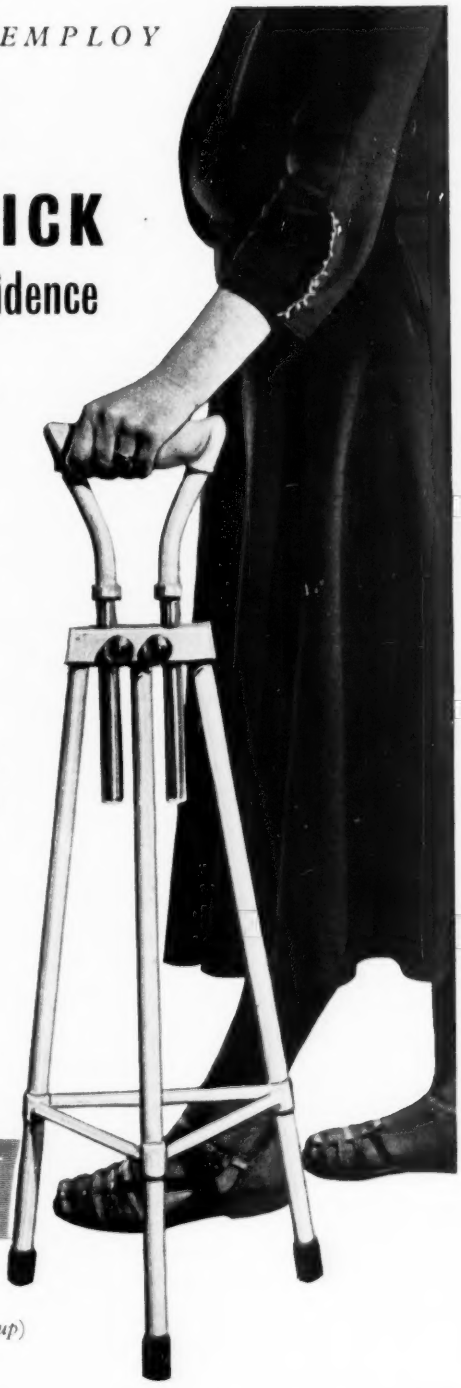
gives the patient confidence



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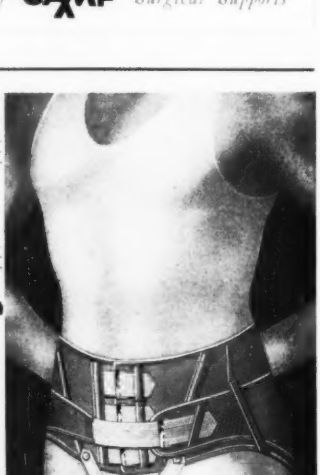

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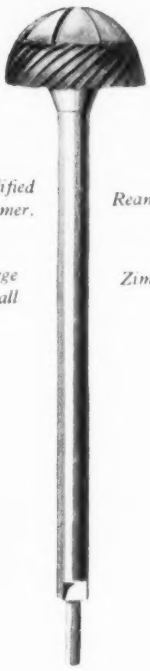

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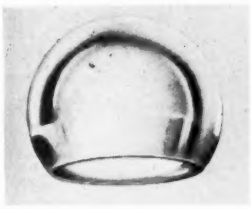

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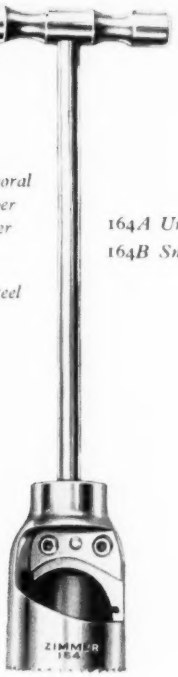

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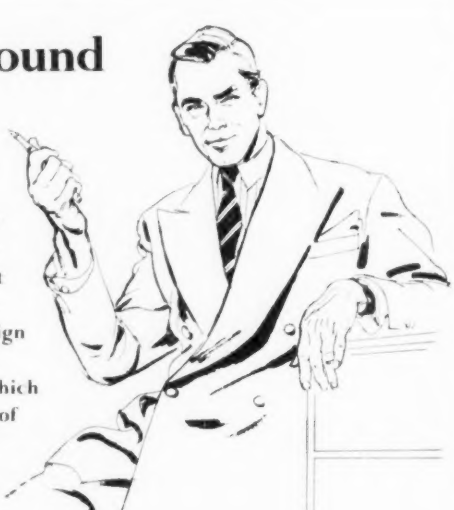

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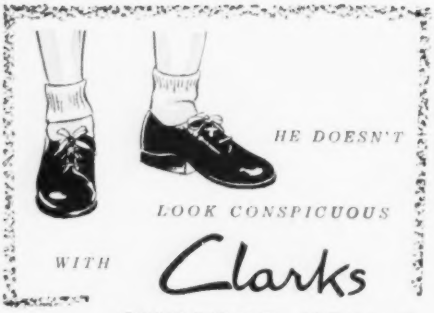

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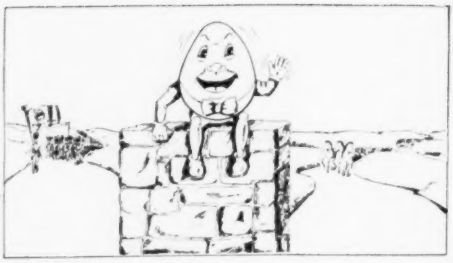

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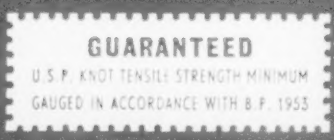

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